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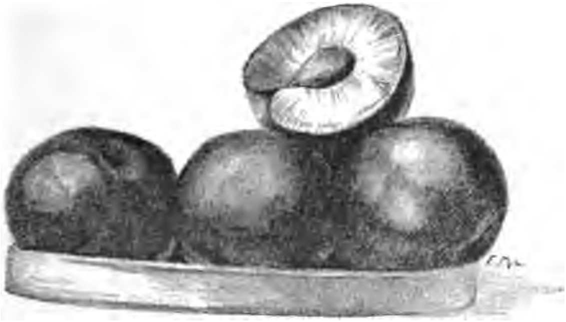
Bulletin 62. **January, 1894.**

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

THE
Japanese Plums
IN NORTH AMERICA.



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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.

CO-OPERATIVE TEST OF SUGAR BEETS.

In the Spring of 1893 the Station received a quantity of sugar beet seed from the Agricultural Department, Washington, D. C. This seed was sent to seventy representative farmers of the state, with the request that they co-operate with us in a test of growing sugar beets, and that a sample of a half dozen average beets be sent us in the Fall for analysis. Later in the season blanks of the form indicated below were sent out with the request that they be filled out and returned with the sample of beets at the time of harvesting:

Previous crop
Kind of soil
Date of planting
Date of harvesting
Distance of rows apart
Weight of trimmed beets from one row two rods long
Kind and amount of fertilizers applied
Name of grower
Post Office
County

The samples of seed were sent with the idea of distributing them over the entire state as much as possible and consequently were sent into fifty-one counties. Of the seventy farmers receiving seed thirty-one responded by sending us more or less data concerning the growth of the beets. The majority, however, sent all the data asked of them and thirty sent samples for analysis. The following table gives the names of the growers, their addresses, the yield per acre, the per cent. of sugar in the beets, arranged alphabetically according to the county where grown:

vated crops. Therefore it seems important that our knowledge of them be increased and that it be made easily accessible.

This paper has been prepared as a contribution to such knowledge. The investigation upon which it is based was carried on in the insectary of the Cornell University Experiment Station, and I have been allowed the free use of the entomological collection of the University. The scope of this paper has been somewhat broadened by the addition of figures and discussions of several species not yet found in the Ithaca fauna, kindly given me by Rev. Geo. D. Hulst. These are those numbered 4,6,7,13,17,23 and 27. I am indebted to Dr. C. H. Fernald for the determination of several species; to Samuel Henshaw for the privilege of examining the collection of *Crambus* in the museum of Harvard University and in the museum of the Boston Society of Natural History; and also to Mr. Wm. Beutenmüller for an opportunity of examining the collection of the late Henry Edwards.

The genus *Crambus* is world-wide in distribution; species having been described from widely separated countries of each continent and from a number of the larger islands. Over sixty North American species have been catalogued. In Ithaca twenty species occur and, judging from the recorded distribution, this may be regarded as nearly the average number of species that might occur in any one locality on this continent. The various species resemble each other so closely that the characters of almost any species would enable even a non-scientific man to refer the others to this genus.

GENERAL CHARACTERISTICS.—Among grass insects Crambids may be recognized by their peculiar habit of folding the wings partially around the abdomen.* The moths are rather small, slender creatures, with very long snout-like palpi. (Fig. 2.) From their long snout-like palpi they, with many others, have been termed Snout Moths. The larger species are about half an inch long and with wings that spread about an inch. The fore wing often presents pretty designs in silver, gold, yellow, brown, black and white or they may be of a nearly unbroken somber color. The hind wings are usually a white or grayish color. Both fore and hind wings are ornamented with

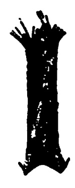

FIG. 2.—*Labial Palps. C. vulgivagellus, enlarged.*

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* In two seasons collecting I have failed to see any similar moths in the grass with this habit.

delicate fringes on the outer margins. The fringes usually have a metallic luster. The antennæ are nearly as long as the body and very slender. The male antennæ are the stouter (Pl. IX, Fig. 18). The eggs of the various species exhibit great uniformity (Pl. XII). They are more or less oval, and have ten to twenty longitudinal ridges and numerous smaller transverse ridges. When first laid the eggs are nearly white, but before hatching they change to a more or less reddish color and in one species they become bright scarlet. The larvæ are about one twenty-fourth of an inch long when first hatched. They usually have dark colored heads and a straw colored body with rows of dark colored tubercles. Upon the head and tubercles small hairs occur. In the different stages of growth the larvæ change in size and depth of coloring, the whole body usually becoming much darker. When full grown the larvæ are from one to two inches long.

HABITS.—Members of this genus fly mostly on dull afternoons and during the early evening. They frequent open fields and the borders of woods. When disturbed the moths rarely fly more than two or three rods at a time. They alight with a peculiar swoop upon a dried stalk of grass, with their heads usually down. These insects dislike a horizontal position very much and will fly some time rather than light upon a flat surface. When at rest upon a stalk of grass the moths are rather difficult to see, as their color harmonizes with their surroundings. So far as is known most of the species live upon grass, including under this term corn, oats, and wheat. Some species may live upon sedges and other coarse grass-like plants. The eggs are usually, if not always, allowed to fall at random in the grass. They hatch in from ten to twenty days. The young larvæ live in cylindrical web-lined nests (Fig. 3.) the outside of which is covered with bits of grass or particles of soil. The nests are usually perpendicular and at or just below the surface of the soil. The larvæ (Fig. 4) feed mostly in the early evening. Some larvæ cut off the blades of grass and draw the end down into the nest so they can feed without leaving the nest. In the early fall the larvæ close the tops of their nests before going into

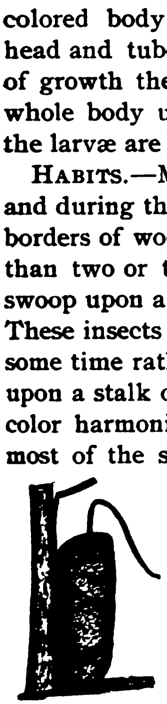

FIG. 3.—*Nest of larva. C. interminellus, enlarged.*

hibernation. In the spring they come forth, complete their growth, pupate near the surface, and later the adults emerge.

ECONOMIC IMPORTANCE.—Though the various species of *Crambus* are common, they have rarely attracted much attention as destructive insects. This is due to their insidious methods of work. Unless the damage they do is very serious it is hardly noticed or, if noticed, attributed to other causes. As the larvæ live a retired life close to the surface, eating mostly at night and remaining in their nests during the day, they are rarely seen. Like most larvæ they feed most voraciously just as they are completing their growth; consequently, when the damage is noticed most of the larvæ are hidden in their retreats where they pupate. In these places none but an experienced entomologist would find them, or would think of associating the damage done with the harmless appearing moths that fly later.

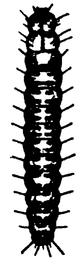

FIG. 4.—*Larva. C. albellus, enlarged.*

Hardly any farmer would think seriously of the loss of only one stalk of grass in ten, yet the aggregate for the country at large would be enormous. Not only is the damage to a crop where nothing short of a serious injury would attract attention, but the damage is distributed throughout the growing season. As a general rule each species is most destructive at a different time from the other species of that locality; hence, species of *Crambus* prey upon the grass as a succession of small armies. Could the loss caused by these species come at one time in the year their destructive power would be better appreciated. Less than a third of the species may be classed as of economic importance, but these possess a capacity to cause almost infinite loss if the conditions are favorable.

In 1880 and 1881 the conditions were favorable for the development of several species of Close Wings. The Vagabond Crambus (*C. vulgivagellus*) was the chief offender, though the Dried Crambus (*C. interminellus*) was associated with the former in the devastation. In the latter part of May, 1881, Dr. Lintner was notified of a "formidable invasion of the grass lands of St. Lawrence County, N. Y., by the army worm." He writes: "The ravages had only been observed during the preceding ten days, but already had they reached such magnitude that many extensive pastures had been completely ruined. The entire destruction of both the pastures and meadows was threatened, and serious detriment to the important dairy interests of the northern counties of the State was anticipated. Hundreds of acres of pasturage in the town of Potsdam had been destroyed, and not a single farm, it was believed, had escaped attack. An upland pasture, containing fifty acres, which, ten days previous to my visit, had afforded good pasturage, was now entirely brown. No grass could be seen in glancing over its whole extent, except a narrow strip which had been used as a roadway when farming purposes necessitated occasional passing from one field to another. This from some unknown reason had remained green." Fortunately, such destructiveness seems to be the exception, though there are a number of species almost as common and as prolific as the Vagabond Crambus.

In 1885, Forbes, in the 14th Report on the Insects of Illinois, records the destruction of corn by the Corn Root Worm (*C. zeellus*). In 1891, L. Bruner reports the same insect injuring corn in Nebraska and several other states. The Vagabond Crambus is also charged with injuring small grains. In Bulletin 14 of the Delaware Experiment Station for December, 1891, the Sooty Crambus (*C. caliginosellus*) is reported injuring corn in that section, the injury having been noticed as early as 1886 at Bennings, Md. In the Annual Report of the Maine State College and Experiment Station for 1891 a species of *Crambus* is charged with injuring the apple in the same manner as the Codlin Moth. Prof. Munson writes: "In many cases the casual observer would attribute the injury to the Codlin Moth, when in reality it is due to another insect—a species of *Crambus*. The larva of this moth is smaller than the Codlin Moth and works only in the calyx. This insect was quite abundant the past season."

Though the various species of *Crambus* are reported as damaging cultivated crops to a considerable extent, yet in most cases it is the result of unusual conditions. The moths are grass insects and incline to remain in the pastures and meadows. The larvæ are also inclined to remain in or near one place. If cultivated fields are near grass lands the moths will fly into them more or less and drop eggs wherever they fly; these eggs hatch and the larvæ seek food. Again, if grass land is plowed there are more or less of these larvæ seeking food. In either case if the larvæ can feed upon the crop planted, it does, and loss must follow. This seems to be the way most of the cultivated crops are injured. In some cases these insects seem to have become established in the field, but in the majority of cases the greatest injury is on the edges of the field near grass land. In view of these facts it is hardly probable that members of this genus will ever become serious pests in cultivated fields.

PREVENTIVE MEASURES.—In the egg and early larval state these insects seem very susceptible to unfavorable conditions. In most cases climatic conditions or insect enemies may be depended upon to keep these small pests in check. When natural forces prove inefficient, recourse must be had to artificial means.

I know of no experiments in combating these pests, and but little has been suggested. The principal contribution to this phase of the subject was made by Dr. Lintner in his First Report as State Entomologist.

Burning.—This was recommended in the late fall or early spring in order to destroy the larvæ while hibernating. Some species hibernate above ground and upon these it would be very effective.

Applications of ashes, lime, gas lime, plaster, dust, etc.—A trial of these substances was recommended, but there is no record of their being used.

Rolling the ground.—This was advised on limited areas.

Trap-lanterns.—An examination of the record of any species taken in the trap-lanterns near the Cornell insectary during the years of 1889 or 1892 will show that the greater number taken were males, except *C. laqueatellus* where the females were in excess. If we accept the strong probability that one male can fertilize* several females, the trap-lantern is of little value. In the case of *C. laqueatellus* the females were examined and only one was found with an abdomen distended with eggs. The females fly but little before most of their eggs are laid, consequently the trap-lantern as a practicable means of checking the

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*In the summer of 1891 the writer observed a male Gypsy Moth (*Ocneria dispar*) copulate successively with three females.

increase of these insects is of no value. The same is probably true of other attractions, as molasses, and vinegar or beer, etc.

Deep plowing.—This was recommended as preventive of a second attack.

To prevent injuries to cultivated crops.—In most cases the easiest preventive is to surround these crops that are near the grass with a strip one or two rods wide of some crop upon which the larvæ cannot feed, as potatoes. There may be instances where a species has become firmly established in a cultivated field, because the same crop has been grown for a series of years. A change to some other crop upon which the larvæ cannot feed would probably rid the field of them.

METHODS OF STUDY.—The study of this genus was begun by the writer in July, 1892. Throughout the remainder of that season and during the season of 1893, continuous collecting supplied the material studied. The first care was to secure fresh unrubbed females which were heavy with eggs. These females were placed in tightly corked homeopathic vials with a few blades of green grass. Under these conditions they would live a week or more and lay freely. Besides those in the vials a number of females were usually placed in a breeding cage and observations were made upon each lot. The most convenient breeding cage was made by placing a lamp chimney over grass growing in a small flower pot; the top of the lamp chimney was covered with muslin. The pot was placed in a larger one and packed with sphagnum moss to prevent undue drying. In such a cage very nearly natural conditions were secured. The eggs in the vials were subject to daily observations and when they hatched the larvæ were described, some preserved in alcohol, and the rest placed in a cage. During the larval existence frequent observations were taken and full notes were made at the time of observation; whenever practicable, drawings were made. During the winter of 1892–93, all the larvæ died from some unknown cause. On this account it has been impossible to complete the round of life of the species studied.

In 1889, the Entomological Division of the Experiment Station ran six trap-lanterns throughout the season, and during the season of 1892 one. From the material taken in these trap-lanterns the periods of flight have been worked out and the number of each sex taken determined. In the determination of species I found the male genital organs to be of great value. Many individuals after being in the trap-lantern could not be recognized by the markings. After a little experience it was only a few minutes' work to expose the genitalia of a softened individual. These organs, after the insect is softened, can be pushed into sight with a point of a pin and a glance is usually enough to determine the species.

VENATION OF THE WINGS.—The figures illustrating the venation of the wings are made from camera lucida drawings of bleached specimens. Great care was taken to represent accurately the outlines of the wings and the courses of the veins, but it was impracticable to use the same scale of enlargement for all; this has been done, however, on Plates XIII and XIV.

The nomenclature of wing veins adopted is that of Redtenbacher as modified by Professor Comstock in his essay on Evolution and Taxonomy. It seems unnecessary to describe the specific characteristics of the venation as these are shown in the plates better than I can describe them. Within the genus there are some specializations worthy of note. In the fore wing, vein III is five-branched except in *C. minimellus*, where it is but two-branched; vein VII is apparently four-branched in all the species except *C. minimellus*, where vein V_2 has coalesced with vein V_3. In the hind wing the frenulum is a single stout spine in the male, while in the female it consists of two distinct spines except in *C. caliginosellus* and *C. hulstellus*, where it is divided at the tip only. The base of vein III is more or less rudimentary and a stump of vein $V_{2\&3}$ persists in some cases. Vein VII is apparently four-branched except in *C. minimellus*, where it is but three-branched.

STRUCTURE OF THE EXTERNAL REPRODUCTIVE ORGANS.—As no one writer, to my knowlege, has used a complete set of comprehensive terms for these important organs, it will be necessary to define the nomenclature used. In the male there are two pairs of lateral clasping organs, termed collectively, the *clasps* (Pl. V, Fig. 1, *v* and *h*). In this genus the outer pair appear to be more or less protective in function and are termed *valves* (Pl. V, Fig. 1, *v*). The inner pair are more or less chitinous and function as grappling hooks, the *harpes*. (Pl. V, Fig. 1, *h*.) Between the clasps is a more or less chitinous organ, the intromittent organ or *penis*. (Pl. VII, Fig. 10, *pn.*) Dorsad of the penis and working vertically is a more or less beak-shaped organ, the *uncus*. (Pl. V, Fig. 1, *u.*) Articulated with the uncus and working vertically with it is a more slender Y-shaped organ, the *lower limb* of the uncus. (Pl. VIII, Fig. 16, *l.*) The penis extends between the branches and dorsad of the body of the lower limb of the uncus. The uncus and the lower limb function as vertical forceps, the clasps as lateral forceps. The uncus and the lower limb are articulated to an inverted keel-shaped organ, the *scaphium*. (Pl. V, Fig. 1, *s*). The scaphium is composed of a pair of sclerites the *members* of the scaphium. (Pl. VIII, Fig. 14, *m*, *m.*) In some species the two members of the scaphium are loosely united. (Pl. XI, Fig. 26, *m*, *m*); in other species the scaphium seems to be composed of a single sclerite. In the female the oviduct is guarded exteriorly by a pair of lateral plates, the *genital plates*. (Pl. V, Fig. 2, *g.*) The walls of the vagina are chitinous and in some species there are chitinous processes which are evidently correlated with the chitinous processes or hooks on the penis. (Pl. VII, Fig. 10, *pn.*) Later we will discuss the modifications of these organs in detail.

SYNOPSIS OF SPECIES.

Three tables are given. The first is purely artificial and is simply intended as an aid in the identification of the species. In the second the period of flight of the various species is presented in a condensed form. The third table is based largely upon a study of the exterior genital organs; in this table an effort is made to indicate the affinities of the species.

TABLE FOR THE SEPARATION OF SPECIES OF CRAMBUS.

A. Fore wings some shade of gray, not yellowish.
  B. Markings dark fuscous with brownish flecks, indistinct; size small; male antennae not pectinate. Pl. XIII., Fig. 2. *2. caliginosellus.**
  BB. Markings quite distinct, a distinct subterminal line.
    C. Only a blackish spot on the tip of the discal cell; male antennae pectinate. Pl. XIII., Fig. 5. *5. mutabilis.**
    CC. An oblique rather irregular discal stripe; size large; male antennae not pectinate. Pl. XIII., Fig. 3. *3. interminellus.**

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* The species marked with an * were taken at Ithaca.

CCC. Large irregular blackish markings on and near tip of discal cell; size large; male antennae pectinate. Pl. XIII., Fig. 4. *4. hulstellus.*

AA. The greater part of the fore wings yellow or of a brownish color.

B. Markings rather obscure, ground color yellow.

C. No subterminal line.

D. Fore wing an unbroken yellow. Pl. XIII., Fig. 1. *1. luteolellus.**

DD. Fore wing shaded with dark scales, black dots at tips of veins. Pl. XIII., Fig. 9. *9. vulgivagellus.**

CC. A more or less distinct subterminal line.

D. Fore wing a dark yellow. Pl. XIII., Fig. 7. *7. teterrellus.*

DD. Fore wings a light yellow.

E. Markings a light rufous, regular. Pl. XIII., Fig. 6. *6. decorellus.**

EE. Markings dark rufous, irregular. Pl. XIII., Fig. 8. *8. ruricolellus.**

BB. Markings distinct.

C. A single broad white discal stripe.

D. Stripe not interrupted near the tip of the discal cell.

E. Stripe extending to the outer margin.

F. Stripe broad, scarcely narrowed beyond tip of discal cell and broadly expanded at outer margin. Pl. XIII., Fig. 10. *10. unistriatellus.**

FF. Stripe narrowed beyond discal cell and broadly expanded at outer margin. Pl. XIII., Fig. 12. *12. hastiferellus.**

FFF. Stripe almost interrupted, but extending by very narrow white line to the expanded tip at the outer margin; size small. Pl. XIV., Fig. 17. *17. extorralis.*

EE. Stripe not extending to the outer margin.

F. Tip of stripe simple. Pl. XIII., Fig. 11. *11. leachellus.**

FF. Tip of stripe bifid. Pl. XIII., Fig. 13. *13. praefectellus.*

DD. Stripe interrupted near tip of discal cell.

E. Fore wing broad, outer margin nearly straight, tip obtuse. Pl. XIV., Fig. 24. *24. alboclavellus.**

EE. Fore wing narrow, outer margin strongly curved, tip acute.

F. Stripe not branching near middle of discal cell. Pl. XIV., Fig. 25. *25. floridus.**

FF. Stripe branching near middle of discal cell, the branch extending along vein VII_2 almost to the subterminal line. Pl. XIV., Fig. 27. *27. satrapellus.*

CC. Two white stripes on the discal cell separated by a well defined rufous stripe of nearly equal width.

D. Only black dots at the tips of the veins on the outer margin. Pl. XIV., Fig. 22. *22. agitatellus.**

DD. Black dots and black lines extending from the dots along the veins almost to the subterminal line. Pl. XIV., Fig. 26. *26. laqueatellus.**

CCC. No white discal stripe.

D. A rather indistinct silvery discal stripe; size very small; apex of wing acute. Pl. XIV., Fig. 23. *23. minimellus.*

DD. No discal stripe.

E. Fore wing marked longitudinally with irregular dull black lines on a dull yellowish background. Pl. XIV., Fig. 19. *19. topiarius.**

AAA. Ground color fore wings white.

B. Fore wing nearly pure white. Pl. XIV., Fig. 18. *18. innotatellus.**

BB. Fore wings not pure white.

C. Markings black. Pl. XIV., Fig. 16. *16. turbatellus.**

CC. Markings a rich brown. Pl. XIV., Fig. 15. *15. elegans.**

CCC. Markings yellowish and black.

D. A longitudinal yellow stripe. Pl. XIII., Fig. 14. *14. giradellus.**

DD. No longitudinal yellow stripe, subterminal line bordered with light yellow. Pl. XIV., Fig. 20. *20. albellus.**

TIME OF FLIGHT OF SPECIES OF CRAMBUS AT ITHACA, N. Y.

	May.	June.	July.	August.	September.
Crambus					
laqueatellus Clem.........	*	* *			
leachellus Zinck...........		* *	* *		
luteolellus Clem...		* *	* *		
floridus Zell................		* *	* *		
giradellus Clem.....		* *	* *		
albellus Clem.......		* *	* *		
interminellus Walk......		* *	* *		
mutabilis Clem............		* *	* *	* *	*
topiarius Zell........			* *		
alboclavellus Zell.........			* *	* *	
caliginosellus Clem.......			* *	* *	
elegans Clem...............			* *	* *	
ruricolellus Zell...........				* *	
vulgivagellus Clem......				*	* *

Each * represents approximately two weeks.

SYNOPTICAL TABLE.

A. Species that are grayish or dark colored. The free portion of the valve at least five times as long as broad. (*The Caliginosellus Division.*)

B. Clasps nearly equal.

C. No accessory spine; clasps not anchylosed at the base. Pl. V., Fig. 2. *caliginosellus.*

CC. An accessory spine; clasps anchylosed at base. Pl. V., Fig. 3. *interminellus.*

BB. Clasps unequal.

C. Harpe broadened. Pl. V., Fig. 4. *hulstellus.*

CC. Harpe reduced to a stout spine. Pl. V., Fig. 5. *mutabilis.*

AA. Species that are yellowish or some shade of red. In the more specialized forms (in all described here except *C. luteolellus*) the free portion of the valve is less than five times as long as broad. (*The Luteolellus Division.*)

B. Generalized representatives of the *luteolellus* division. The clasps are nearly equal and are at least five times as long as broad. Pl. V., Fig. 1. *luteolellus.*

BB. Specialized representatives of the *luteolellus* division. The valves are less than five times as long as broad.

C. Valve nearly triangular; harpe more or less reduced; accessory spine slender when present. (*Subdivision I.*)

D. No accessory spine; general color yellow; harpe greatly reduced. (*The Decorellus Group.*)

E. Harpe strongly recurved.

F. Harpe rather long, irregular. Pl. VI., Fig. 6. *decorellus.*

FF. Harpe short, regular, bifid. Pl. VI., Fig. 7. *teterrellus.*

EE. Harpe not strongly recurved.

F. Harpe short, tip acute. Pl. VI., Fig. 8. *ruricolellus.*

FF. Harpe shorter, tip obtuse. Pl. VI., Fig. 9. *vulgivagellus.*

DD. Accessory spine present.

E. Uncus and lower limb nearly equal; color rufous with a broad white discal stripe. (*The Unistriatellus Group.*)

F. Harpe long, strongly recurved at tip. Pl. VII., Fig. 10. *unistriatellus.*

G. Discal stripe near costa at base of wing, stripe extending to outer margin.* Pl. XIII., Fig. 12. *hastiferellus.*

GG Stripe near center of discal cell, not extending to outer margin.

H. Tip of stripe simple. Pl. XIII., Fig. 11. *leachellus.*

HH. Tip of stripe bifid. Pl. XIII., Fig. 13. *praefectellus.*

EE. Uncus greatly reduced in length. (*The Giradellus Group.*)

F. Accessory spine at base of valve. Pl. VIII., Fig. 14. *giradellus.*

FF. Accessory spine near apical third of valve. Pl. X., Fig. 25. *floridus.*

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* I cannot separate these species on the male geniatalia.

CC. Valve not triangular; harpe elongate and with one or more spines near the tip. (*Subdivision II.*)
  D. An accessory spine near the tip of the harpe. Pl. VIII., Fig. 15. *elegans.*
  DD. Many short spines on the tip of the harpe. Pl. VIII., Fig. 16. *turbatellus.*
  DDD. A pair of spines on the tip of the harpe forming a crescent as seen from behind. Pl. VIII., Fig. 17. *extorralis.*

CCC. Valves strongly flattened; harpe never elongate and narrow; accessory spine when present broad and plate-like or very short. (*Subdivision III. The Agitatellus Group.*)
  D. Harpe nearly as wide as valve.
    E.. Harpe terminated by a retangular spine, edge smooth. Pl. X., Fig. 22. *agitatellus.*
    EE. Harpe terminated by a recurved spine, and with chitinous processes upon the edge. Pl. IX., Fig. 18. *innotatellus.*
  DD. Harpe much narrower than the valve at the base. Pl. X., Fig. 23. *minimellus.*
  DDD. Harpe reduced to a very short spine.
    E. A thick tuft of very long hairs near the harpe. Pl. IX., Fig. 19. *topiarius.*
    EE. No thick tuft of very long hairs near the harpe. Pl. IX., Fig. 20. *albellus.*
  DDDD. Harpe not a short spine.
    E. Uncus not strongly reduced, tips of valves oval.
      F. Harpe flattened, recurved. Pl. X., Fig. 24. *alboclavellus.*
      FF. Harpe flattened, concave, curved ventrad. Pl. XI., Fig. 26. *laqueatellus.*
    EE. Uncus greatly reduced, represented by two very thick tufts of curved hairs. Pl. XI., Fig. 27. *satrapellus.*

DESCRIPTION OF SPECIES.*

1. THE YELLOW CRAMBUS.

Crambus luteolellus.

PLATES I., V., XIII., Fig. 1.

This species may be recognized by its uniform yellow color and by its small size. This insect is confined to low wet lands. The moths fly about dusk during the latter part of June and July. Females were very hard to find and those taken laid but few eggs, which failed to hatch.

Egg.—A light rufous color when first laid. Form elliptical oval; size .42 by .3 mm. There are about fourteen prominent longitudinal ribs and numerous smaller transverse ridges.

2. THE SOOTY CRAMBUS.

Crambus caliginosellus.

PLATES I., V., XII., XIII., FIG. 2.

This species is a small dark colored moth with quite obscure markings. The adults fly in the early evening during the latter part of July and the first week of August. Very few of the moths are attracted to light. In the six trap-lanterns run through the season of 1889 only four males were taken, yet the species is quite common in Ithaca. Like the Yellow Crambus, this species is mostly confined to low wet lands. This insect appears to be more prolific than the Yellow Crambus; one female laid two hundred and seventy-five eggs in a vial, and this is probably below the average.† When first laid the eggs are a creamy white. They gradually turn to an orange rufous color, and hatch in from five to eight days.

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* For a discussion of the more technical characteristics, and of those species the habits of which were not observed, see concluding part of this paper, treating of the Affinities of the Species.

† It is only occasionally that a female is taken in the field before she has laid any eggs. As a rule, I give the highest number of eggs I have observed any one female of a species to lay and then give the probable average based upon observations of other females of the same and other species. The numbers of eggs laid by a single female was determined by actual count and not by estimates.

The habits of the larvæ are thus described by M. H. Beckwith:* "This species does not penetrate the plant (corn) and remain feeding upon the tender inner parts, but works upon the outer portion just beneath the surface of the soil. Some plants were nearly girdled, and the worms were frequently found imbedded in cavities where they had fed upon the plants. In some instances as many as thirty worms were found in a single hill of corn. In many hills the plants had been entirely destroyed; in others they were small and had a yellow, sickly appearance. The greatest injury appeared to have been caused in that portion of the field adjoining a small strip of timothy sod that remained without plowing." In all probability this injury was caused by the moths flying into the field from the adjoining grass and dropping their eggs in the field. The eggs hatched and the larvæ had no other food, hence the injury to the corn.

Egg.—Creamy white when first laid, gradually turning to an orange rufous color before hatching. Form elliptical-oval with the ends slightly truncate; size .39 by .3 mm. The egg-shell has eighteen longitudinal ribs and numerous smaller transverse ridges. Pl. XII., Fig. 2.

Larva, first stage.—Head diameter .15 mm.; body diameter .125 mm.; length .875 mm. Color a smutty translucent white with irregular reddish spots on the middle line of the back; head a pale amber color. Scattered light colored hairs occur on the head and body. Five pairs of prolegs, occur on the seventh to tenth inclusive, and thirteenth segments.†

3. THE DRIED CRAMBUS.

Crambus interminellus.

PLATES I., V., XII., XIII., Fig. 3.

This insect is a rather large ashy gray moth with two irregular, oblique black markings upon the fore wing. This species seems to prefer low wet land. The moths fly mostly at or just after dark; they are attracted to light in large numbers but, as in most species, the majority taken are males.‡

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* Bulletin No. XIV, Delaware Agricultural Experiment Station.

† This is true of all the species studied.

‡ H. Osborn records a predominance of females loaded with eggs. Insect Life, Vol. VI, No. 2, p. 72.

Trap Lantern Record. *C. interminellus*, 1889.

	June.																			July.										Aug.	Total.
	1	4	5	6	8	10	11	12	13	14	15	16	17	18	19	20	21	25	27	2	5	6	7	8	9	10	15	17	21	30	
Males . .	1	3	8	1	1	5	11	1	1	4	1	2	1	1	1	4	4	1		2	1	5	3	3	1	1			1	1	69
Females .	3						1			1	5		3						1		1					2	1	1			19

The period of flight extends through June and July; individuals have been taken as late as September 30. This long period of flight indicates great irregularity in time of breeding, but this does not necessarily imply more than one generation a year.

This species is quite prolific; one female laid one hundred and fifty eggs after capture and confinement in a vial. From observation of other species the average is probably between three and four hundred and one might expect to find individuals laying over five hundred eggs. When first laid the eggs are of a pale yellowish color; they gradually turn to an orange buff color and hatch in about eight days. The larvæ begin to feed soon after hatching. Their favorite position is in the axil of a leaf, where they eat the soft parenchyma. Even when but a few days old the larvæ eat most voraciously. When the larvæ are about a week old they begin to spin webs in the axils of the leaves; frequently several leaves are fastened together, in the midst of which the larvæ feed. When grass is not to be had the larvæ will feed upon sheep sorrel (*Rumex acetosella*). About a month after hatching, the last of September, the larvæ begin to construct cylindrical perpendicular nests near the surface of the soil (Fig. 5). These nests are usually attached to one or more stalks of grass. The outside of the nest is covered with finely chewed bits of grass, while the inside is smoothly lined with silk. The nests are about a quarter of an inch long and about one-sixteenth of an inch in diameter. A little later the nests are strengthened by the addition of more grass to the outside. Occasionally a large piece of grass is woven into the side of the nest, but usually the pieces are small and of nearly equal size. As cold weather approaches, about November 1st, the larvæ

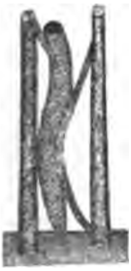

Fig. 5.—*Nest of larva. C. interminellus, enlarged.*

retire for the winter. The most of them close their nests with bits of grass before hibernating. Some of the nests have an underground chamber and passage way, which may allow the exit of the larvæ during mild days and also give access to the roots of the grass.

According to Dr. Lintner* the larvæ come forth in the spring, complete their growth, and pupate in June. The pupa state lasts about fifteen days. In this insect there seems to be no delayed pupation as has been recorded of the Vagabond Crambus. This species is very prolific and capable of causing considerable loss.

Egg.—A cream yellow color when first laid, gradually turning to an orange buff color before hatching. Form nearly elliptical; size .48 by .33 mm. The egg-shell has sixteen strong, longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 3.

Larva, first stage.—Head diameter, .225 mm.; body diameter, .15 mm.; length, 1.2 mm. Head black, thoracic shield a dark brown; body a translucent white with numerous small black tubercles, each tubercle bearing one or more light colored hairs. Scattered light hairs occur upon the head.

When about half grown (late fall) the larva is 2 cm. long. The head and tubercles are black while the body is a mottled chocolate brown with a black stripe extending along the dorsal line.

Early in the spring the larva is about 3. cm. long. The head and thoracic shield are of a dark amber color; tubercles of the same color; there is a dull pinkish line along the middle line of the back; there are also irregular dark wavy subdorsal and lateral lines; body a pale straw color.

Pupa.—Thorax and head brown; abdomen rufous; spiracles dark brown; length about 2 cm.

Cocoon.—Oval, composed of a thick layer of bits of grass with particles of soil adhering to the outside. Inside, the cocoon is smooth and thinly lined with silk. The cocoon was made just below the surface.

5. THE DARK SPOTTED CRAMBUS.

Crambus mutabilis.

PLATES I., V., XIII., Fig. 5.

This species may be recognized by the dark spot near the middle of the slaty fore wing. There is also a dark subterminal line, which is usually rubbed so as to give the appearance of a second dark spot. This insect is larger than the Sooty Crambus and may be readily reeognized by the pectinate antennæ of the male. The moths fly in the latter part of the afternoon and in the early evening. The species is confined to low or damp land; they are also attracted to lights.

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* First Report on Insects of New York, 1882, p. 149.

TRAP LANTERN RECORD. *C. mutabilis*, 1889.

	June.											July.									August.				Sep.		Total.
	4	5	7	10	12	14	15	16	17	18	19	5	6	7	8	10	12	13	14	17	11	15	19	24	5	8	
Males.	1	1	1	1	1	2	1	4	2	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	3	36
Females . .			1				1	2									1										5

This table shows that the adults fly through June, July, August, and into September. A similar record for 1892 is given by the single trap-lantern run that season. This is an exceptionally long breeding season. There may possibly be two generations in a year, but the weight of evidence seems against it.

The period of oviposition extends over a week or more. One female laid two hundred eggs the day after being taken, two hundred the next day, and one hundred the third day; at the end of a week she died, having laid seven hundred and twenty-five eggs after capture. Observation shows this is probably above the average. The eggs are a creamy white color when first laid but they soon change to a bright rufous color, and hatch in about ten days. All the moths laid a very large number of eggs, but the larvæ died soon after hatching; this seems to be the weak point in the life-history of this species.

Egg.—Creamy white when first laid, gradually turning to an orange rufous color before hatching. Form elliptical oval; size .51 by .36 mm. The egg-shell has sixteen longitudinal ridges and numerous small transverse ridges.

Larva, first stage.—Head diameter .18 mm.; body diameter .15 mm.; length 1.1 mm. Head pale yellowish with a sprinkling of sooty specks;* body a rather sooty semi-transparent white with irregular rufous blotches along the dorsum; scattered dark colored hairs occur on the head and the body.

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* In descriptions of larvæ written in 1892 the head is black and the body considerably darker than given above, undoubtedly there is some variation.

7. THE BLUE GRASS WORM.

Crambus teterrellus.

PLATES I., VI., XII., Fig. 7.

This species has not been found in Ithaca, although it occurs in New York State. The moth may be recognized by its dark yellow color, the silvery subterminal line bordered by dark rufous, and by the black dots upon the outer margin at the tips of the veins. In Missouri this species is reported to outnumber all the other species of *Crambus*. The moths are most abundant about the first of August. The eggs are salmon color. The larvæ are a dingy white, and are found in galleries of fine white web in the grass. The web and the grass near by become sprinkled with the castings. In the dry weather of August and September larvæ were found on withered portions of a lawn, and they were evidently responsible to a considerable degree for the faded appearance and scanty growth of the blue grass during the latter part of the summer.

Miss Murtfeldt says:* "The growth of the larvæ was very slow and seemingly out of all proportion to the amount of web tubing constructed. A single larva, not more than one-third of an inch long, seemed to require for its domicile a gallery of 2 to 2½ inches in length and with a diameter two or three times its own. The upper part of this tube would be exceedingly diaphanous, but as it descended more and more of the frass was intermingled until at the base it became quite compact. During the day the larva rested quietly in this retreat, but at night it emerged and fed upon the freshest of the contiguous blades. So far as I could ascertain it seldom or never cut through the stalk or bored up or down through the heart of the plant.

The larvæ seemed to attain maturity from the middle to the last of September, after which they rested quietly for some time in their galleries, without inclosing themselves in more protective cocoons."

This apparent maturity was probably the cessation of active feeding, preparatory to hibernating. As the adults do not fly till

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* Miss Murtfeldt, Bulletin No. 30, U. S. Department Agriculture, Entomological Division, p. 53.

August, it is probable that the larvæ hibernate when partially grown and complete their growth in the spring.

Later, in the jar containing specimens collected at various ages from the lawn, Miss Murtfeldt "found the remains of two or three hymenopterous parasites and four cocoons of the characteristic form, color and structure of *Meteorus*, closely resembling those of *M. hyphantriæ*."

Egg.—Obconical 0.5 mm. long, beautifully sculptured under the lens, with longitudinal ridges and finer cross lines, giving it a checkered appearance. Color, bright salmon pink.

Larva.—At first of a dingy cream white, minutely speckled with brown, with brown head.

At maturity 15 mm. in length, by 2 mm. in diameter, subcylindrical, slightly larger across thoracic segments. Color yellowish or greenish white, with dull green medio-dorsal stripe. The surface is much roughened with impressed lines, with conspicuous, raised corneous plates, from each of which rises a long, coarse, tapering yellow golden hair. Head with protruding lobes and rugose surface and of a dull whity brown color. Cervical shield inconspicuous, darker than the head.

(These descriptions of the egg and larvæ are quoted from Miss Murdfeldt's account.)

8. THE RUSTIC CRAMBUS.

Crambus ruricolellus.

PLATES II., VI., XII., XIII., Fig. 8.

In 1892, this species was very abundant in Ithaca, N. Y., flying with, and to the casual observer, appearing the same as the Vagabond Crambus. The two species are very similar, especially when the specimens are somewhat rubbed. The Rustic Crambus has two irregular oblique rufous markings on the fore wing, while the Vagabond Crambus has no design upon the fore wings. This species is most abundant around damp places and near forests. The moths fly mostly on the early evening, though in dark or shady places they are quite abundant in the afternoon. At times they emerged in swarms, so one sweep of the net captured three or four individuals. The period of flight is limited mostly to the month of August. They are not attracted to lights in large numbers.

TRAP LANTERN RECORD. *C. ruricolellus*, 1889.

	August.						September.	Totals.
	16	23	24	25	29	30	1	
Male................	1	2	4	1	2	1	1	12
Female..............			3					3

As in most species, a large preponderance of males is here noticeable.

When first laid the eggs are creamy white in color; they gradually turn to an orange buff color, and hatch in about twelve days. The young larva has a black head and a brick red body. For about ten days the larvæ appeared to eat very little; possibly they did not like young timothy (*Phleum praetensis*). After a time the grass was eaten with avidity; clover was left untouched, while sheep sorrel (*Rumex acetosella*) was eaten. When not feeding the larvæ remained close to the stalks of grass or attempted to hide under the sheath. Where there is old growth the larvæ frequently bore through the stalks or leaves; in these places they soon spin a web which conceals them more or less completely. When disturbed the larvæ coil into a helix if on a leaf; if close to a good retreat they quickly disappear among the grass stalks. As cold weather comes on the larvæ feed more during the day. Late in the season, about the middle of October, the larvæ disappear from the leaves and the base of the stalks, and construct snug retreats just under the surface of the soil. The soil is pushed up into a crumbly mound under which the larva forms a silk-lined cavity. The entrance to these nests is usually by a tunnel or covered passage way about half an inch long. The nests are frequently constructed around the base of several stalks of grass, which the larvæ eat off at their leisure. These nests were made among young grass where there were no dead leaves, etc. In old sod similar nests are constructed, except that the outside of the nest is strengthened with bits of grass and other material. As the season advances the larvæ become darker colored till their bodies are almost a brownish black. On the approach of cold weather the larvæ feed less and less and finally retire for the winter; at this time they average about one-fourth of an inch long. The larvæ failed to survive the winter, and, as this insect is closely related to the Vagabond Crambus, the remainder of its life history is probably very similar.

Egg.—Creamy white when first laid, gradually turning to an orange buff color before hatching. Form elliptical oval; size .41 by .33 mm. The egg-shell has twenty longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 8.

Larva, first stage.—Head diameter .225 mm.; body diameter .175 mm.; length 1.2 mm. Head nearly black; thoracic shield a dark reddish brown; body whitish translucent with many pale rufous spots on the dorsum of the fifth to the twelfth segments inclusive. Scattered dark colored hairs occur on the head and body.

Late in the fall the head and thoracic shield are almost black, the pale rufous spots have developed into dark brown tubercles, and the body has become deep brown.

9. THE VAGABOND CRAMBUS.

Crambus vulgivagellus.

PLATES II., VI., XII., XIII., Fig. 9.

This insect is a very ordinary appearing moth. The fore wings are a dull yellowish color flecked with black and with black dots on the outer margin at the tips of the veins. The labial palpi are very long and are flecked with black. The rest of the insect is of a more or less yellowish gray color. In spite of its commonplace appearance, this insect is very interesting economically.

The adults fly about dusk during the latter part of August and the first half of September.

TRAP LANTERN RECORD. *C. vulgivagellus*, 1889.

	August.									September.												Totals.
	19	20	23	24	27	28	29	30	31	1	3	4	5	8	9	10	11	12	14	17	18	
Males . .	2	2	12	6	3	4	2	14	2	5	6	1	7	9	3	1	3	3	1	1	1	88
Females .				3	1					1	1		3	8		4	1					22

The moths are attracted to light in large numbers, but mostly males are taken. In shady places the moths fly more or less during the day. This insect is very prolific; one female laid three hundred and twenty eggs after capture; this is probably below the average number, as her abdomen was but moderately distended with eggs.

When first laid the eggs are a pale yellow color, but they gradually turn to a more or less deep rufous color, and hatch in from sixteen to thirty days, the time varying with conditions. While young the larvæ may usually be seen coiled up on a leaf in plain sight when not feeding; if disturbed, they remain quiet for a minute and then try to escape or they may drop at once by a thread of silk. As cold weather comes on the larvæ feed mostly during the day; occasionally they may be seen feeding in the early morning. When very young they eat only the soft parenchyma of the leaf, later the whole leaf is devoured. They feed mostly upon grass, though they will eat small grains. This species was bred in the hollow flower stalk of a species of wild parsley,* by H. G. Hubbard. The larvæ seemed to have fed mostly upon the soft pith. The pupæ were inclosed in a finely spun thin cocoon and frass was thickly strewn over the cocoon.

According to Dr. Lintner,† the larvæ commence feeding in the spring with the starting of the grass. They feed principally by night and remain in a cylindrical tube composed of silk and bits of grass, when not feeding.

Dr. Lintner says: "The depredations, when serious, are conspicuously noticeable when the larvæ are about three-fourths grown—about the middle of May.

When nearly mature the larvæ from some unknown cause, congregate in immense numbers on the trunks of trees near the ground.

When mature, about the 25th of May, they abandon their green cases, and build long cylindrical earthen cocoons, placed upright in the ground just beneath the surface.

The larvæ remain unchanged in the cocoons for two months or more, through June and July, when they transform to pupæ. The pupa state continues about two weeks."

Natural enemies.—Of the true parasites there are *Lampronata frigida* Cress., an Ichneumon Fly; *Cryptus mundus* Prov.;

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* See label in Museum of Comparative Zoölogy, Cambridge, Mass.

† First Report on Insects of New York, 1882, p. 144.

Perilampus violaceous Dalm., a Chalcid; and also a species of *Tachina*, a fly.

Besides the true parasites a number of predaceous insects have been observed to prey upon this species of *Crambus*. Most prominent of these are a number of Carabid or Ground Beetles and several species of ants.

Egg.—A pale straw color when first laid, gradually turning to an ochraceous buff color before hatching. Form elliptical oval; size .45 mm. by 36 mm. The egg-shell has twenty longitudinal ridges and numerous smaller transverse ridges Pl. XII., Fig. 9.

Larva, first stage.—Head diameter .19 mm.; body diameter .175 mm.; length 1.25 mm. Head a dark brown; thoracic shield olive, and the body a straw yellow color. Scattered light colored hairs occur on the head and on the numerous small brownish tubercles on the body.

Larva, late in the fall.—2.5 mm.long. Head jet black; thoracic shield a deep brown; body brown with deep brown tubercles. The fifth to thirteenth segments inclusive are divided into cephalic and caudal portions by a short transverse constriction.

II. LEACH'S CRAMBUS.

Crambus leachellus.

PLATES II., VII., XII., XIII., Fig. 11.

While not very abundant, this species has a wide distribution, having been taken in Illinois, Pennsylvania, Texas, New York, and Venezuela. It probably occurs in most of the United States and in corresponding latitudes in South America. The species is easily recognized by the silvery white stripe in the middle of the dull rufous fore wing; the stripe extends almost to the tip of the wing. The adults fly mostly in the late afternoon and during the early evening. They are attracted to light.

TRAP LANTERN RECORD. *C. leachellus*, 1889.

	June.					July.			Total.
	1	10	13	14	16	6	8	9	
Male			1	1	1	1	1	1	6
Female	1	1							2

The table and observations in the field show that this insect has no sharply defined period of flight. A few individuals may be found almost any time in June or July.

The egg state of this species is of special interest because it exhibits some of the most marked changes in color. When first laid the eggs are a creamy white color ; within twenty-four hours they change to a scarlet and the next twenty-four hours the color deepens to a geranium red. After the second day the eggs change but little in color. They hatch in about ten days. As the egg-shell is very thin the black head of the embryo shows through it with great distinctness. Soon after hatching the larvæ begin to feed most voraciously. Slight nests (Fig. 6) are spun on the blades of grass under which the larvæ retires when not feeding. Others spin a web in the axils of the leaves. In these nests frass is allowed to collect. As the larvæ become larger they build the more typical cylindrical nest at the base of the stalks of grass; these nests are strengthened on the outside with finely chewed bits of grass and they usually extend about half an inch below the surface. As the larvæ continue to grow the nests are built anew or enlarged and at this period the larvæ adopt the cut-worm habit and eat off blades of grass* and draw one end into the nest. Some of the nests contained finely chewed bits of green grass evenly packed around the inside of the nest This material seemed to serve as reserve food.

FIG. 6.—*Nest of larva. C. leachellus.*

About the first of August the larvæ construct a dense hibernaculum. The outside is thickly covered with bits of grass and particles of soil, while the inside is smoothly lined with silk. The rest of the life history is yet to be worked out.

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* The writer observed a larva cut off a blade of grass and then pull the end down into its nest. The larva ate the blade nearly off and then pulled several times on a free corner but it was unable to tear the piece away ; finally after repeated pulling and cutting at the base of the leaf, the larva succeeded in tearing loose the prize and fell with it to the ground, the blade lying upon the ground. The larva next dragged the base of the leaf to the mouth of its nest and then by repeated pulls upon a corner succeeded in bringing the blade to a perpendicular position and then in drawing the base of the blade down into the nest. The whole was carried on with almost human intelligence ; the repeated cutting and pulling reminded me of a man alternately cutting and pulling at a tree.

Egg.—Creamy white in color when first laid, quickly changing to a scarlet and then to an intense geranium red; just before hatching the blackish head of the embryo shows through the thin shell very distinctly. Form nearly oval; size .51 mm. by .39 mm. The egg-shell is quite fragile and frequently collapses when the larva leaves it. There are twenty-two longitudinal ridges and numerous smaller transverse ridges. The circular markings around the micropyle are very characteristic Pl. XII., Fig. 11.

Larva, first stage.—Head diameter .21 mm.; body diameter .18 mm.; length 1. mm. Head a brownish black, clypeus yellowish, antennæ nearly colorless, scattered hairs occur on the head; thoracic shield brown with a reddish tinge from the body contents; body a variable red, the color being the most intense in the thoracic region; there is a light stigmatal line; tubercles blackish and bearing dark hairs; prolegs almost rudimentary.

When about a month old the larvæ are 1.5 cm. long; the head is yellowish with irregular black markings; the body is brown with large blackish tubercles. When about six weeks old the larvæ are 3 cm. long and quite stout; the color has not changed.

14. THE YELLOW STRIPED CRAMBUS.

Crambus giradellus.

PLATES II., VIII., XIII., Fig. 14.

This moth is one of the largest Crambids. The adults may be recognized by the rather broad yellow stripe extending through the middle of a nearly pure white fore wing. This insect is confined to high land and is usually found in open fields. The moths fly in the afternoon and during the early evening. Light seems to have little attraction for them; in 1889 only four adults were taken in the trap-lanterns. The species is not very abundant, though widely distributed. The moths fly the latter part of June and more or less during July. Oviposition covers a period of from several days to a week; most of the eggs being laid during the first few days. Observation of other species shows that the average female probably lays about four hundred eggs; one female laid two hundred and twenty-five eggs in four days; she had doubtless laid some before being captured. The eggs hatch in about ten days. The larvæ feed upon grass and construct the typical Crambid nest. (Fig. 7).

Egg.—Creamy white when first laid, gradually changing to a bright orange color before hatching. Form elliptical oval; size .51 mm. by .33 mm. The egg-shell has seventeen longitudinal ridges and numerous smaller transverse ridges.

Larva, first stage.—Head diameter .24 mm.; body diameter .21 mm.; length 1.05 mm. Head and thoracic shield a glistening black; body a reddish straw color; scattered hairs occur on the head and body; the hairs on the body grow from minute tubercles which are concolorous with the body.

When about a month old the larvæ are 2. cm. long. The head is yellowish with irregular brown markings; the body is a slate color with brown tubercles.

15. THE PRETTY CRAMBUS.

Crambus elegans.

PLATES III., VIII., XII., XIV., Fig. 15.

This insect is a very pretty little moth. When the wings are folded it is readily recognized by the brown horse-shoe shaped mark upon the center of its back. The whole insect is marked in a rather irregular manner with brown on a white background. This species is not very abundant, yet by no means rare; it is quite generally distributed over the United States. It is found almost entirely upon high land and is frequently quite abundant near wet springy places. The moths fly mostly in the latter part of the afternoon and in the early evening. Though this insect is quite common in Ithaca, none were taken in the trap-lanterns. In Ithaca the adults fly during the most of July and the first half of August. They fly slower than most species and with a more irregular flight; their movement is so characteristic as to be easily recognized. The eggs hatch in from twelve to fourteen days.

Egg.—Creamy white when first laid, gradually turning to an orange buff color before hatching. Form oval; size .42 mm. by .30 mm. The egg-shell has sixteen longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 15.

Larva, first stage.—Head diameter .2 mm.; body diameter .125 mm.; length 1.09 mm. Head and thoracic shield light brown; body a dirty straw color. Scattered hairs occur on the head and body.

18. THE UNMARKED CRAMBUS.

Crambus innotatellus.

PLATES III., IX., XII., XIV., Fig. 18.

This species is not very abundant around Ithaca, only one female being taken in 1892. None were taken in the trap-lanterns.

The few taken were captured in the early afternoon. This species has been taken in Maine, New Hampshire, and New York. The eggs hatch in about two weeks.

Egg.—Creamy white when first laid, gradually changing to a scarlet color before hatching. Form elliptical oval; size .45 mm. by .36 mm. The egg-shell has sixteen longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 18.

Larva, first stage.—Head diameter .19 mm.; body diameter .15 mm.; length 1.05 mm. Body a dull straw color with irregular reddish blotches on the dorsum. Scattered light colored hairs occur on the head and body.

19. THE GARDEN CRAMBUS.

Crambus topiarius.

PLATES III., IX., XII., XIV., Fig. 19.

This species may be recognized by its small size and its linear markings of yellow and silver gray combined with short black lines and dots. This insect flies in large numbers with the White Crambus; the period of flight is practically limited to the month of July.

TRAP LANTERN RECORD. *C. topiarius*, 1889.

	July.													Totals.
	5	7	8	9	10	12	13	14	15	17	18	26	28	
Males ...	2	11	7	7	1	1	7	4	1	1	7	1	1	51
Females		3						3		1	1			8

This species flies most of the afternoon, and considerably after dusk as indicated by the trap-lantern record. This insect occurs on both high and low land, though not common in wet places. It is one of the most common Crambids in New York.

The species is very prolific; one female laid seven hundred eggs, three hundred being laid the first day. This is undoubtedly above the average. The eggs hatch in about ten days. The young larvae are very active and strong; they soon begin to construct the typical cylindrical nest (Fig. 7), composed of web and an outer layer of bits of dry grass. The bits of grass are cut with great regularity, being about 2 mm. by 75 mm. In these nests the larvae retire when not feeding. The larvae feed upon the common grasses. Some were observed to eat considerable sheep sorrel (*Rumex acetosella*). The larvae feed mostly at night and occasionally a blade of grass was cut off and the end drawn into a nest. As cold weather came on the larvae became more dormant, the nests were made thicker, and finally in November the tops of the nests were closed. The winter is passed in the larva state. In the spring the larvae complete their growth and then transform, and emerge in July.

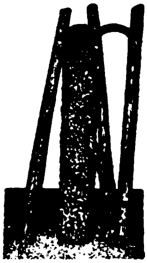

FIG. 7—*Nest of larva. C. topiarius, enlarged.*

Egg.—Creamy white when first laid, gradually turning to a pinkish red color before hatching. Form elliptical oval; size .40 mm. by .30 mm. The egg shell has twenty longitudinal ridges and numerous small transverse ridges. Pl. XII., Fig. 19.

Larva, first stage.—Head diameter .2 mm.; body diameter .125 mm.; length .99 mm. General color a smutty white; head a little darker than the rest of the body. Scattered dark hairs occur on the head; numerous small dark colored tubercles occur on the body, each bearing at least one hair

20. THE WHITE CRAMBUS.

Crambus albellus.

PLATES III., IX., XII., XIV., Fig. 20.

This insect may be recognized by its white color with a few pale oblique markings, and by its small size. The adults fly the greater part of June and July. They fly mostly in the latter part of the afternoon and more or less during the whole of cloudy days. They rarely fly at twilight and therefore are not attracted to lights. During the two seasons trap lanterns were run by the Experiment Station only two males were taken. When found in the grass the moths rarely attempt to fly, but remain quiet till there is an opening, when they quickly glide out of sight among the dead grass. This insect is confined almost exclusively to high, rather dry land; they are most abundant in open fields.

The eggs hatch in about ten days. The young larvae soon construct cylindrical nests (Fig. 8), which are mostly above ground and are lined with silk, while the outside is strengthened with irregular bits of grass or particles of soil. The larvae remain in these retreats when not feeding, and frass is allowed to collect at the bottom of the nests. If a larva is removed from its nest it soon constructs another. Several larvae were observed to voluntarily forsake their nests and build elsewhere, which was probably due to the accumulation of frass in the old nest. The larvae feed mostly upon the common grasses. As cold weather advances the nests are built higher and more grass or other material is fastened to the outside of the nests. Finally, in November, just before retiring for the winter, the larvae close the tops of their nests with grass and a web, and hibernate in these retreats.

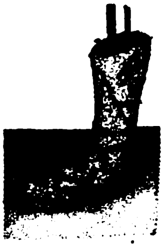

FIG. 8.—*Nest of larva. C. albellus, enlarge.d*

Egg.—Creamy white when first laid, gradually turning to a pale straw color before hatching. Form nearly oval; size .39 mm. by .33 mm. The egg-shell has eighteen longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 20.

Larva, first stage.—Head diamter .175 mm.; body diameter .125 mm.; length .75 mm. General color a smutty white, head darker, and thoracic shield a little darker than the body. Scattered brown hairs occur on the head; rows of numerous small tubercles occur on the body. Fig. 4.

24. THE WHITE STRIPED CRAMBUS.

Crambus alboclavellus.

PLATES IV., X., XIV., Fig. 24.

This species is very common in Ithaca. The moths fly mostly the latter part of the afternoon and during cloudy days; they do not fly much after dark, as the trap-lantern record shows.

TRAP LANTERN RECORD. *C. alboclavellus*, 1889.

	July.					Total.
	4	17	18	22	24	
Males	1	2	2	2	2	9
Females			1			1

The moths fly mostly during July and the first half of August. This insect is one of the larger Crambids and is easily recognized by the broad white stripe near the edge of the wing. This stripe is broken by an oblique rufous line near the outer third of the wing; and the basal half of the stripe is divided longitudinally by a faint yellowish line. This species is quite prolific; one female has been known to lay five hundred and twenty-five eggs. The eggs hatch in about ten days.

The young larvae are strong and begin to feed at once. They soon construct nests of the typical form. (Fig. 7.) As the larvae grow older their straw colored bodies become darker till in September they are a mottled dark brown. Early in November the larvae close their nests and retire for the winter. In the spring the larvae complete their growth, pupate, and emerge as adults in July.

Egg.—Creamy white when first laid, gradually turning to an orange buff color before hatching. Form elliptical oval; size .42 mm. by .33 mm. There are about sixteen longitudinal ridges and numerous smaller transverse ridges.

Larva, first stage.—Head diameter .225 mm.; body diameter .14 mm.; length .625 mm. Head a deep brown, thoracic shield a lighter brown; body a straw color with a reddish mark along the middle of the back from the fourth to the ninth segments inclusive. Scattered light colored hairs occur on the head and body.

25. THE FLOWERY CRAMBUS.

Crambus floridus.

PLATES VI., X., XIV., Fig. 25.

This species resembles in a general way the White Striped Crambus, yet it is quite different in some respects. It may be recognized by the narrower white stripe along the costal edge of the narrower fore wing; the stripe is not broken near the tip nor is it divided longitudinally. The tip of the fore wing is also more pointed and the outer margin more strongly curved than in the White Striped Crambus. The moths fly the latter part of the afternoon and during the early evening.

TRAP-LANTERN RECORD. *C. floridus*, 1889.

	June.						July.				Totals.
	10	11	14	15	17	18	5	10	22	26	
Males............	1	1	2	1	1	1	1	1		1	10
Females.........									1		1

The moths fly the greater part of June and July, though they are not abundant at any time. The insect is confined to high, rather dry land.

The species does not seem to be very prolific. The eggs hatch in about ten days. The young larvæ eat holes through the leaves or feed upon the edge of a leaf. In about two weeks the body becomes a dark mottled brown. At this time they establish themselves in the axil of a leaf or upon its flat surface; here they spin a slight web and soon construct a nest with an outer layer of bits of grass. The larvæ remain in these retreats when not feeding.

Egg.—Creamy white when first laid, gradually turning to a dark scarlet color before hatching. Form elliptical oval; size .39 mm. by .30 mm. The egg-shell has sixteen feeble longitudinal ridges and numerous smaller transverse ridges.

Larva, first stage.—Head diameter .21 mm.; body diameter .15 mm.; length 1.15 mm. Head black, labrum yellowish, scattered hairs occur on the head; thoracic shield a dark brown; body a straw color with fine reddish blotches giving it a pinkish cast. Scattered hairs grow from small dark tubercles.

When about two weeks old the body is a dark mottled brown. When a month old the larva is 1 cm. long.

26. THE PANELED CRAMBUS.

Crambus laqueatellus.

PLATES IV., XI., XII., XIII., Fig. 26.

This species was very abundant in Ithaca in 1893. It is one of our largest species. The moth may be recognized by the two white stripes extending the greater length of the fore wing and separated by a brown stripe of almost equal width. The ground color of the fore wing is brown. This insect is equally abundant upon low as upon high ground, though the period of flight is longer on high ground. The moths fly more or less during the whole afternoon and during the early evening. During the early part of the afternoon mostly males are taken, while toward dark females are more abundant.

TRAP LANTERN RECORD. *C. laqueatellus*, 1889.

	May.			June.														Total.
	20	24	26	2	3	4	5	6	7	8	9	10	11	14	15	16	17	24	
Males.........	1	1	5	3	3		3	2		1		2		3	1	1			26
Females.....	1					1			3		2	2	1	4	6	5	3	1	29

This is the only species of *Crambus* where the number of females taken in a trap-lantern has exceeded the number of males. At first thought the trap-lantern would appear to be of use in checking the increase of this insect, but of all the females taken only one was heavy with eggs. The females seem to possess more vitality than those of other species. This insect is quite prolific; several of the females taken laid over two hundred eggs each, this is probably below the average.

The eggs hatch in about twelve days. The larvæ were quite active, but refused to feed upon timothy and therefore died.

Egg.—Creamy white when first laid, gradually turning to an orange color before hatching. Form subcylindrical; size .42 mm. by .30 mm. There are sixteen longitudinal ridges and numerous smaller transverse ridges. Pl. XII., Fig. 26.

Larva, first stage.—Head diameter .18 mm.; body diameter .15 mm.; length 1.15 mm. Head brownish black with whitish hairs; thoracic shield a light brown; body mottled with pale bright red and bearing blackish tubercles.

ON THE AFFINITIES OF SPECIES.

As might be expected of a large genus, *Crambus* includes several distinct lines of development. In attempting to trace the lines of specialization, the modifications of each organ should receive due consideration. We should go further than that and take into consideration the causes that have led to these modifications.

Before attempting to seek the cause of specialization, it may be well to ascertain just what has occurred within generic lines. In this study, based as it is on less than half of the North American species, one can hardly expect to find unbroken lines of development. We should expect to find gaps in the living forms and much larger ones when only a part of these are represented. Again, the larger the gaps, the greater the liability to error. In this study we shall assume that the better an organ is fitted to perform its functions the more highly specialized it is and, conversely, there may be a specialization by reduction as when an organ becomes useless and there is a reduction of the superfluous part.

The most striking and at the same time most superficial specific characteristics are the markings. As in many other groups of moths, we find that the most generalized species have a rather somber gray or yellow color with indistinct markings. The species studied may be divided into two very natural divisions on color alone. The grayish or dark colored species form a very natural division, the Caliginosellus Division. Later we shall see this division is united by strong structual affinities. The rest of the species are yellowish in color or of a color that may be derived from the yellow, and these represent an entirely different line of development, the Luteolellus Division. The lowest species of this division is *C. luteolellus*, which stands just below *C. caliginosellus* and is closely related to this species; the two probably having sprung from a common ancestor. This division may be divided into groups on color and no violence be done to structual affinities. The first group,. the Decorellus Group, consists of yellowish moths with few or no markings. Next we might separate the Unistriatellus Group by the broad white stripe on a rufous fore wing. But as we attempt to classify the more specialized forms on maculation, we find the variation in color has increased more than structual variations and therefore our conclusions are at fault. In the more specialized forms the tendency to acquire adaptional colors has been greatly increased; consequently color may be a quite reliable systematic character in the more generalized species, but it is not in the more specialized forms.

In the venation there are considerable variations. These variations are useful in indicating the relative degree of specialization of the different forms, but it is more in degree than in kind. In the antennæ there are some specializations and in two species this has been carried to a remarkable extent. In the labial palpi and the other mouth parts there are some modifications but they are of no great systematic value. The relative size of the species is of some value. The more generalized species seem to have a certain medium size from which the more specialized forms have varied each way. In the exterior genital organs there are great variations in form and these are of considerable value in tracing the phylogeny of the species. With the genitalia as the main witnesses and the other organs as subordinate witnesses, we will attempt to trace the affinities of the species. For the general plan of classification see the synoptical table.

1. The most generalized type is seen in *C. luteolellus*. Plates I., V.,XIII., Fig. 1. The valve is elongate, oval in cross section and thickly covered with rather short hairs. The harpe is more chitinous and bears a dense row of rather short hairs. In the primitive *Crambus* the clasps were probably similar independent organs. In this species the uncus is longer than the lower limb, which is more slender. The scaphium is long and keel-shaped. From this simple type of genitalia there have been wide deviations along several lines. This species has the somber yellow color and the medium size of a generalized Crambid. The wings are rather broad and the veins branch nearer the base of the wings than in most species. The antennæ and palps exhibit little specialization. This insect is more closely related to the progenitors of the many species now living than any other form studied. Structurally, this insect is closely related to the Caliginosellus Division, but its color connects it with the lighter colored moths. As color in these more generalized species seems to be a quite reliable character, it may be allowed that *C. luteolellus* is not the progenitor of the Caliginosellus Division but that the separation occurred in a more primitive form. Therefore *C. luteolellus*, while being the most generalized species studied, is most closely related to the insect through which the more specialized forms have come.

The Caliginosellus Division.—Plates I., V., XII., XIII., Figures 2–5.

2. *Crambus caliginosellus*. Structurally this insect is most

closely related to *C. luteolellus* and can be separated only on the form of the scaphium, the form of the other organs being almost identical. Its dark color places it in this division and from this form the others are readily derived.

3. *Crambus interminellus.* This species is more specialized than the preceding as is shown by the narrower fore wing and by the larger size. The antennæ are somewhat specialized, the joints in the male becoming shorter and broader, while in the female a large seta has been developed on each joint; in both sexes the setæ upon the edge are shorter and finer than in the preceding species. The clasps retain the more primitive form but have become firmly anchylosed at the base, and an accessory spine has been developed. The genital plate is smooth and oval quite different from that of *C. caliginosellus*, showing that the species did not come directly from *C. caliginosellus* but in all probability from a more primitive form.

4. *Crambus hulstellus.* In this species the narrowing of the fore wing has been carried to a much greater extent and the veins branch much farther from the base of the wing. The female antennæ exhibit a degree of specialization while the male antennæ are highly specialized. The clasps depart somewhat from the primitive type and are not firmly anchylosed. This departure from the type seems correllated with a lightening in color and a greater distinctness in the markings. The uncus has become somewhat shortened and a distinct hook has been developed. The genital plate, though more specialized, shows a close relationship to *C. caliginosellus.*

5. *Crambus mutabilis.* Though the fore wings are broader than in the two preceding species, this insect is the most highly specialized of the division. The broadening of the wing, in this case, is a secondary development, and has followed as a consequence of the highly specialized male antennæ. When the antennæ became so efficient probably the wings became of secondary importance and consequently the process of narrowing stopped and a retrogression began. In due time the same thing will probably occur in *C. hulstellus.* The valve has retained its more primitive form, but the harpe has been reduced to a very efficient spine. Correlated with the efficiency of the harpe, a reduction of the uncus has taken place. The two members of the scaphium

have become sickle-shaped. The genital plate has nearly the rounded form of *C interminellus* and this species is probably most closely related to that form.

The Luteolellus Division:

As before stated, *C. luteolellus* is placed in this division, but is treated of first, because it is the most generalized form of the species studied.

Subdivision I.

The Decorellus Group.—Plates I., II., VI., XII., XIII., Figures 6-9.

By their larger size and their uniform dull yellow color these species are seen to be more specialized forms than have descended from *C. luteolellus*, or allied species, and not from the dark colored Caliginosellus Group. In fact all the species of this division trace back to *C. luteolellus*.

6. *Crambus decorellus.* This species has a broad generalized wing. The antennæ are somewhat specialized, the joints being shorter and broader than in *C. luteolellus*. The valves are nearly triangular which is a marked departure from the primitive type. The harpe is greatly reduced and strongly curved. The uncus and the lower limb are well developed, probably because the harpe is so reduced and twisted as to be of little use. The scaphium is long and deep.

7. *Crambus teterrellus.* In this species the fore wing has been narrowed. The male antennæ are highly specialized. The valve has about the same form as in the preceding species, while the harpe has become more specialized by reduction in size and by the development of a double recurved hook. In consequence of the greater efficiency of the harpe the uncus has been greatly reduced. The genital plate has a slight tendency toward irregularity in outline.

8. *Crambus ruricolellus.* This species and *C. vulgivagellus* represent a line of development where the harpe has been greatly reduced and is therefore inefficient; the uncus has suffered but little reduction. The valves are more flattened than in the two preceding species. The wing is not so specialized as in *C. teterrellus*, but is more specialized than in *C. decorellus*. The labial palpi are longer proportionally than in *C. teterrellus* and shorter than

in *C. vulgivagellus.* The two members of the scaphium are short and nearly sickle-shaped. The genital plate is quite irregular.

9. *Crambus vulgivagellus.* The narrower wings and the greater development of the labial palpi indicate a higher degree of specialization than in the preceding. The antennæ are also more highly specialized. The harpe has been more reduced, but in other respects the genital organs are almost identical.

The Unistriatellus Group.—Plates II.,VII.,XII.,XIII.,Figures 10–13. The valve has nearly the same form as in *C. decorellus*, but it is more irregular. The harpe has become a stout recurved hook in *C. unistriatellus* but in the other species the harpe is more reduced. There has been developed at the base of the valve an accessory spine. This group was probably separated from a species closely allied to *C. decorellus.* In the Decorellus Group specialization has reduced the efficiency of the harpe and left the uncus comparatively unmodified. In this group the harpe and the accessory spine have become very efficient, while the uncus has become very slender. The uncus seems to be exactly alike in the four species of this group.

10. *Crambus unistriatellus.* This is the most generalized species of the group. In the fore wing none of the veins have become coalesced and the wing is broader than in the other species. The harpe in this group gives no reliable character for separating the species. In this species the harpe is strongly recurved and there are three recurved chitinous hooks on the penis. The genitalia show a high degree of specialization in some ways but the wings place this species as the most generalized.

11. *Crambus leachellus.* The fore wing is narrower than in the preceding and vein V_2 and vein V_3 have coalesced at the base; this has also occurred in the remaining species of this group.

12. *Crambus hastiferellus.* The narrowing of the fore wing and the coalescense of vein V_2 and vein V_3 has been carried still further. The genital plate is more specialized than in *C. leachellus.*

13. *Crambus præfectellus.* This is the most specialized of the group as is seen by the still narrower fore wings.

The Giradellus Group.—Plates II., IV., VIII., X., XIII., XIV., Figures 14 and 25.

14. The two species included in this group are highly specialized

forms. The venation of the species is almost exactly the same. In *C. floridus* the wing is a little narrower and the apex is more acute. The antennæ exhibit about an equal degree of specialization. In both species the valves are nearly triangular, while the harpe retains the elongate form. An accessory spine has been developed, and in *C. floridus* it is at the apical third, while in *C. giradellus* it is at the base of the valve. The species agree in the great reduction of the uncus. If the lower limb be taken as unity, the difference in length between the uncus and the lower limb will give the amount of the reduction. The reduction of the uncus seems to be correlated with the greater efficiency of the harpe or of the accessory spine. In *C. floridus* the uncus seems to be double; both lateral and ventral aspects are figured. The genital plates of the females show considerable similarity. *C. floridus* is the more specialized. The form of the valve and the accessory spine connects this group with the Unistriatellus Group.

Subdivision II.—Plates III., VIII., XII., XIV., Figures 15, 16, and 17.

This subdivision includes three highly specialized forms, which seem to be tips of as many lines of development. They agree in having the harpe highly specialized at or near the tip.

15. *Crambus elegans.* The fore wing is very broad. This generalized condition of the wings is correlated with highly specialized antennæ in both sexes. The tip of the valve is more or less oval. The harpe has coalesced at the base with the valve. There has been a shortening of the harpe and the accessory spine is strongly developed and near the tip of the harpe. Both the uncus and the lower limb seem to have suffered reduction. The form of the genitalia and of the joints of the antennæ seem to show a relation between this species and a form allied to *C. teterrellus.*

16. *Crambus turbatellus.* In this species the fore wing is quite generalized. The branches of the veins are all independent and arise rather near the base of the wing. The antennæ exhibit some degree of specialization. In the clasps there is a marked divergence. The valves have coalesced mesally and the harpes likewise; the harpes have also become anchylosed with the uncus and scaphium. Though the valves are twisted they have the

triangular form of *C. decorellus.* At the base of the valve there is a short flattened spine. The harpe has become highly specialized at the tip, there being on its mesal surface many short chitinous spines. The uncus has become reduced to a slender spine, while the lower limb has suffered little reduction.

17. *Crambus extorralis.* This species has no very close affinities among the species studied. The narrow fore wing indicates a high degree of specialization; all the veins branch near the outer margin of the wing. The antennæ are highly specialized. The primitive elongate form of the clasps connects this species with *C. luteolellus.* At the base of the valve a rudimentary spine occurs and this connects the species with the Unistriatellus Group. At the tip of the harpe a pair of curved spines have arisen. The uncus has been reduced somewhat, though not well shown in the figure. This species stands at what might be termed the head of a straight line of development.

Subdivision III. The Agitatellus Group.—Plates III., IV., IX., X., XI., XII., XIV., Figures 18–27, except figure 25.

This group represents a line of development from forms in which the clasps became broadly and equally developed before other morphorlogical changes occurred. This group includes the most specialized forms and, as might be expected, great diversity in form occurs in the genital organs.

18. *Crambus innotatellus.* In this species the fore wing is rather broad and the veins are independent. The antennæ are not highly specialized. The clasps are broad and nearly equal. Upon the edge of the harpe a row of chitinous processes has been developed, which terminates in a stout recurved hook. The uncus has been strongly reduced and modified. While the genitalia exhibit considerable specialization, it is what might be termed a sidewise development, and from the ancestors of this form, or a closely allied species, the next two species have arisen. The genital plate has been strongly modified.

19. *Crambus topiarius.* The broad fore wing and the independence of most of the veins stamp this species as more generalized than *C. albellus.* The male genitalia are similar. In each the harpe has been reduced very much. The valves are broad, flattened and convex mesally, but in *C. topiarius* a tuft of very long hairs has been developed at the base of the harpe. As a

consequence of the inefficiency of the harpe the uncus has remained comparatively unmodified and strong chitinous hooks have been developed on the penis. The hooks on the penis are undoubtedly correlated with chitinous processes in the vagina.

20. *Crambus albellus.* The wings are narrower than in the preceding species. Here the strongly reduced harpe is evidently correlated with the chitinous processes at the external orifice of the vagina. The valve, uncus, and lower limb are about the same as in *C. topiarius.* Chitinous processes on the penis would appear superfluous, as the harpe is made very efficient by the processes on the vagina, hence there is no such development as occurs in *C. topiarius.* The genital plate of the female is more specialized than in *C. topiarius.*

22. *Crambus agitatellus.* The venation of this species is almost the same as in *C. innotatellus;* the difference being no greater than might be expected within specific lines. The clasps are nearly equal and are not so specialized as in *C. innotatellus.* The same is true of the uncus and the genital plate. On the penis a stout recurved hook has been developed. The antennæ are more specialized than in *C. innotatellus.* These two species possess a nearly equal degree of development. This species is placed here because it leads most naturally to the following species and they are most closely related to the most specialized forms; it is really the most generalized species of this group.

23. *Crambus minimellus.* In this species the fore wings are most highly specialized. Radius is but two-branched in the fore wing, while media is but two branched in both fore and hind wings, vein V_2 having coalesced to the tip with V_3. In this species the high degree of specialization exhibited by *C. extorralis* has been carried still further, but along a different line. The separation probably occurred below *C. agitatellus.* The clasps are simply modified from *C. agitatellus* and for this reason this species is placed in this group. Though the wing is the most specialized, it seems most natural to place the insect next to *C. agitatellus,* regarding the modifications of the wings as a sidewise development.

24. *Crambus alboclavellus.* The fore wing is almost the same as *C. agitatellus,* being only slightly narrower. The antennae are a little more specialized, there being a large seta upon the side of

each joint. The tip of the valve has become more oval and the harpe has been reduced to a recurved flattened process. A short accessory spine occurs but it is very different from the accessory spine of the Unistriatellus Group. The uncus is very similar to that of *C. agitatellus* and like it has suffered little reduction. The genital plate is more specialized than in *C. agitatellus.*

25. *Crambus floridus.* See No. 14.

26. *Crambus laqueatellus.* This species is undoubtedly a more specialized form that has arisen from the progenitors of *C. agitatellus* or a closely allied form. The venation is almost identical, though the wing is a little narrower and exhibits a higher degree of specialization. The antennae are more specialized. The harpe has become shortened and strongly modified; both the spur of the harpe and the accessory spine are flattened concave processes, while a chitinous bar extends across the base of the valve. The uncus and the lower limb are well developed and closely resemble those of *C. agitatellus.* The members of the scaphium are loosely united and elongate. The genital plate is highly specialized and is similar to *C. agitatellus.*

27. *Crambus satrapellus.* This species has the narrowest fore wings and the apex is most prolonged. The veins are independent and branch near the margin. The antennae are not very highly specialized. The harpe is very efficient as is also the accessory spine. The form of these organs connect this species with *C. laqueatellus.* The uncus seems to have disappeared completely and a pair of very thick tufts of curved hairs has been developed. The other forms studied throw no light upon this singular modification. A study of other species will probably throw much light on this question.

Thus far the classification has been based entirely upon morphological studies. In no case has it been assumed that a species has descended directly from any species now living. The referring of species to each other was only to indicate relationship; the connecting links between the species have disappeared in all probability. Behind these great modifications of the genital organs there must be some plan, and if these forms have been rightly interpreted, we might expect to find some vital relations between closely allied species. In short, vital and morphorlogical facts should harmonize.

A study of the adult moths shows little change except in the antennae, wings, and genitalia, but in neither antennae nor wings are there variations enough to lead us to regard them as the prime characters which separated any species. In the immature stages there is a great similarity among all the species studied. This similarity among the species in both adult and immature stages may be explained by the great similarity of habit. So far as is known the species of *Crambus* are grass insects. Throughout the growing season the grass offers practically the same conditions; hence great variation in the organs concerned in the function of nutrition could hardly be expected. The species are so small and require such a relatively small amount of food, that many individuals can exist upon a small area. The grass is so open and the moths fly so readily that there is little need of highly specialized organs to facilitate the finding of a mate; consequently in the secondary sexual organs we find a rather uniform degree of development.

In the male genitala there are great variations. These variations may be explained by the almost uniform abundance of food throughout the growing season. If grass is kept cut or grazed rather close to the ground, as it frequently is in nature, it grows throughout the season. Under these conditions the insect that fed continously throughout the growing season, and was not more destructive at one period than another, would succeed best in the struggle for existence. Like many larvæ, *Crambus* larvæ are more destructive just as they are completing their growth. A genus of insects might become adapted to these conditions by having several generations in a season or by breaking up into a number of species, each having a different breeding season. In *Crambus* there are a number of species in a locality breeding once a year, but at different times. Among the primitive Crambids the abundance of food at other than the usual period of larval existence would tend to preserve any variations in the time of breeding. Those individuals exhibiting the greatest variations in the time of breeding would naturally pair, and should any structural variations arise whereby pairing with individuals conforming more closely with the usual breeding time might be rendered difficult, such variations would be preserved by natural selection. A slight variation in the male genitalia might render crossing difficult and in time lead to the separation of a species. The great variations in these important organs found in this genus lead us to this conclusion.

The record of species now living shows that variation in the time of breeding has most probably occurred in the genus, and is even now taking place. *C. laqueatellus* has a compact breeding season of about five weeks ; *C. interminellus* has a breeding season extending through June and July and with a few individuals appearing the latter part of August, while *C. mutabilis* flies through June, July, August and into September. See Time of Flight of Species of *Crambus*. (Table p. 58.) This shows there is great variation in the length of the period of flight. If variation in time of flight is the first step in the separation of a species, we would expect closely allied species to have nearly the same period of flight. Secondly, we should expect that only the most specialized forms would fly earliest and latest. This is also borne out by the record. *C. laqueatellus*, *mutabilis*, and *C. vulgivagellus* are highly specialized forms and stand at the heads of different lines of development. The periods of flight of these species diverge most widely from the time when the more generalized forms fly. The closely allied species of these highly specialized forms have periods of flight which overlap the periods of their more specialized relatives.

That variation occurs in the genitalia is shown by members of the Unistriatellus Group. With the exception of *C. unistriatellus*, I have been unable to separate the species of this group by the character of the genitalia.

The genus *Crambus* has been adapted to its environment by a multiplication of species, which resemble each other in many respects, yet are well separated, as a rule, by variations in the male genitalia. A glance at the time of flight of the species shows that members of the various species fly throughout the growing season and that they are most destructive in June and July, the time when their food is most abundant.

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Crambus agitatellus Clem.
Habitat. Mass., N. Y., Ill., Tex., London, Ont.
1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 203.
1863 Zeller.* Mon. (p. 21); (*saltuellus*) ibid. p. 22.
1872 Zeller. Abhand. k.k. zool. bot. Gesellschaft. Vienna.
1874 Packard. Record Am. Ent.
1875 Zeller. Beiträge† p. 92.
1880 Grote. Can. Ent., XII., p. 77 (*saltuellus*); ibid. p. 77.
1887 Saunders Can. Ent., XIX., p. 26.

Crambus albellus Clem.
Habitat. Me., Mass., N.Y., L.I., N. J., Penn., Can., Ont., Lab.
1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 204.
1863 Zeller. Mon., p. 23.
1864 Packard. Proc. Ent. Soc. Phil., II., p. 418.
1880 Grote. Can. Ent., XII., p. 78.
1887 Saunders. Can. Ent., XIX., p. 26.

Crambus albilineellus Fern.
Habitat. South Cal.
1893 Fernald. (Orig. Des.) Can. Ent., XXV., p. 94.

Crambus alboclavellus Zell.
Habitat. Mass., N. Y., N. J., Va., O., Ill., Ky., Tex., Ont.
1863 Zeller. (Orig. Des.) Mon., p. 19.
1872 Zeller. Verh. z-b Wien., XII., 535–540.
1875 Zeller. Beiträge, p. 92.
1880 Grote. Can. Ent., XII., p. 77.
1886 Moffat. Can. Ent., XVIII., p. 31.
1887 Saunders. Can. Ent., XIX., p. 26.

Crambus anceps Grt.
Habitat. Cal
1880 Grote (Orig. Des.) Can. Ent., XII., p. 18.; ibid. p. 78.

Crambus argillaceellus Pack.
Habitat. Lab.

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* Chilo et Crambidarum genera et species; in Programm der Koeniglichen Realschule in Meseritz.

† Beiträge zur Kenntnis nordamerican Nachtfalter.

1868 Packard (Orig. Des) Proc. Bos. Soc. Nat. Hist., II., p. 32.

Crambus attenuatus Grt.

Habitat. Cal., Columb., Vanc. Is.

1880 Grote. (Orig. Des.) Can. Ent., XII , p. 18; ibid p. 78.

1881 Grote. Can. Ent., XIII., p. 67.

Crambus auratellus Clem.

Habitat. Mass.

1860 Clemens. (Orig. Des.) Proc. Acad. Nat. Sci. Phil., p. 204.

Crambus bidens Zell.

Habitat. Me , Mass., N. Y.

1872 Zeller. (Orig. Des.) Abhand. k.k. Zool. bot. Gesellschaft Vienna, Taf. III. fig. 17.

1874 Packard. Record Am. Ent.

1875 Zeller. Beiträge I , p. 89; id. Verh. z-b. Wien, XII.

1880 Grote. Can. Ent., XII., p. 77.

Crambus biothanatalis Hulst.

Habitat. Cal.

1886 Hulst. (Orig. Des) Trans. Am. Ent. Soc., XIII., p. 166.

1887 Fernald. (*behrensellus*) Ent. Am., III., p. 37.

Crambus bolterellus Fern.

Habitat. Tex.

1887 Fernald (Orig. Des.) Ent. Am , III., p. 37.

Crambus caliginosellus Clem.

Habitat. N. Y., Col., Hamilton, Ont.

1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 203.

1880 Grote. Can. Ent., XII., p. 79.

1887 Saunders. Can. Ent., XIX., p. 88.

1891 Beckwith, H. M. Bull. Del. Coll. Agr. Expt. Stat. No. XIV., p.1 3.

Crambus carpenterellus Pack.

Habitat. Mountains of Cal.

1873 Packard. (Orig. Des.) Hayden's U. S. Surv., p. 548, fig. 1.

Crambus comptulatalis Hulst.

Habitat. Vancouver's Island.

1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc , XIII., p. 167.

Crambus cuneolalis Hulst.

Habitat. Tex.

1886 Hulst. (Orig Des) Trans Am. Ent. Soc , XIII., p 166.

Crambus cypridalis Hulst.

Habitat. Utah.

1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 165.

Crambus decorellus Zinck.

Habitat. Mass., Md., Tex., Penn.

1819 Zincken. (Orig. Des.) Germ. Mag., IV., p. 250.

1863 Zeller (*polyactinellus*) Mon., p. 25.

1875 Packard. Record Am. Ent., p. 19.

1875 Zeller. Beiträge, I., p. 92.

1880 Grote. (*goodellianus*) Can. Ent., XII., p. 17 and 78.

1888 Fernald.=(*polyactinellus* Zell., *goodellianus* Gr., and *bonusculalis* Hulst.) Ent. Am., IV., p. 44.

Crambus delectalis Hulst.

Habitat. Arizona.

1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 165.

Crambus dissectus Grt.

Habitat. Me., N. Y.

1880 Grote. (Orig. Des.) Can. Ent., XII., p. 16; ibid., p. 78.

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1882 Grote. Papilio, II., p. 73.

Crambus dumetellus Hub.

Habitat. Cal.

1886 Hulst. (*trichusalis*) Trans. Am. Ent. Soc., XIII., p. 165.

Crambus edonis Grt.

Habitat. Kan.

1880 Grote. (Orig. Des.) Can. Ent., XII., p. 19; ibid., p. 79.

1880 Grote. N. Am. Ent., I., p. 68, fig. 11, Pl. V.

Crambus elegans Clem.

Habitat. N. Y., N. J., Ill., L. I., O., Pa., Tex., Md., Hamilton, Ont.

1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 204.

1872 Zeller. (*terminellus*) Stett. Ent. Zeit., p. 473, Fig. 5, Pl. II., id, Abhand. k. k. z-b. Gesellschaft, Vienna; id,=(*terminellus*) Vehr. z-b. Wien., XXII., p. 535-540.

1874 Packard. Record Am. Ent.

1875 Zeller. Beiträge, p. 93.

1880 Grote. Can. Ent., XII., p. 78.

1886 Moffat, J. A. Can. Ent., XVIII., p. 31.

Crambus extorralis Hulst.

Habitat. Fla.

1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 165.

Crambus floridus Zell.

Habitat. Mass.

1875 Zeller. (Orig. Des.) Beiträge, I., p. 91; id. Verh. z-b. Wien., XXII., p. 537.

1880 Grote. Can. Ent., XII., p. 77.

Crambus gausapalis Hulst.

Habitat. Sier. Nev.

1886 Hulst (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 167.

Crambus giradellus Clem.

Habitat. N. H., N. Y., L. I., O., Pa., Md., London, Ont., St. Martin's Falls, Albany River, Hudson's Bay, N. Am.

1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 204.

1863 Walker. (*nivihumellus*) Brit. Mus. Cat., XXVII., p. 159.

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1872 Lintner. Ent. Contributions, I., p. 184.

1878 Lintner. Ent. Contributions, IV., p. 38.

1880 Grote. Can. Ent., XII., p. 77.

Crambus hastiferellus Walk.

Habitat. Pa., Fla., La., Tex., Nova Scotia.

1863 Walker. (Orig. Des.) Brit. Mus. Cat., XXVII., p 155.

1877 Zeller. (*quinqueareatus*) Microlep., p. 38, Tf. I, fig. 16.

1878 Butler. A. G. (*quinqueareatus*) Ill. Lep. Het., II., p. 40, fig. 16.

1880 Grote. (*quinqueareatus*) Can. Ent., XII., p. 77.

Crambus hulstellus Fern.

Habitat. Tex.

1885 Fernald. (Orig. Des.) Can. Ent., XVII., p. 56.

Crambus innotatellus Walk.

Habitat. Me., N. H, Mass., N. Y., O., Ill., Cal., Can., Ont., Quebec, Nova Scotia, New Brunswick.

1863 Walker. (Orig. Des.) Brit. Mus. Cat., XXVII., p. 155.

1863 Walker. (*inornatellus*) ibid, p. 157.

1863 Zeller. (*sericinellus*) Mon., p. 49.

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1881 Moffat, J. A. (*sericinellus*) Can. Ent , XVIII., p. 31.

Crambus interminellus Walk.

Habitat. Me.,N.H., Mass , N.Y., Ill., Neb., Vanc. Island, Can., London, Ont., Nova Scotia.

1863 Walker. (Orig. Des.) Brit. Mus. Cat., XXVII.

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Habitat. Lab.

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1863 Walker. Brit. Mus. Cat. No. 27, p. 155.

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Crambus laciniellus Grt.

Habitat. Me., U. S.

1880 Grote (Orig. Des.) Can. Ent., XII., p 18 : ibid.p. 78.

Crambus laqueatellus Clem.

Habitat. Mass., N. Y., O., Ill , Ky., Tex., La.

1860 Clemens. (Orig. Des.) Proc Ass. Nat. Sci. Phil., p. 203.

1863 Walker. (*semifusellus*) Brit Mus. Cat. No. 27, p 159.

1863 Zeller. Mon., p. 24.

1872 Zeller. Abhand. k. k. z-b. Gesellschaft. Vienna.

1872 Lintner. Ent Contributions, I, p. 184.

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1875 Zeller. Beiträge., p. 91.
1880 Grote. Can. Ent., XII., p. 78.

Crambus leachellus Zinck.

Habitat. Me., Mass., N. Y., L. I., N. J., Pa., Ga., Ill., Cal., Tex., Vancouvers Island, Hamilton, Ont., Venezuela, Mendocino.

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1873 Packard. Rec. Am. Ent.
1875 Zeller. (*pulchellus*) Beitrage, p. 89.
1880 Grote. Can. Ent., XII., p. 16 and 77.
1887 Saunders. Can. Ent., XIX., p. 26.

Crambus luteolellus Clem.

Habitat. N. Y., Cal., London, Ont.

1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 203.
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Crambus minimellus Rob.

Habitat. Pa., Tex.

1870 Robinson. (Orig. Des.) Ann. N.Y. Lyc. Nat. Hist., p. 315.
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Crambus multilineellus **Fern.**

Habitat. Fla.

1887 Fernald. (Orig. Des.) Ent. Am., III., p. 37.

Crambus mutabilis Clem.

Habitat. Mass., Conn., N. Y., O., Ill., Cal., Ky., Fla., La., Neb., Tex., Hamilton, Ont.

1860 Clemens. (Orig. Des.) Proc. Ass. Nat. Sci. Phil., p. 204,
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1891 Bruner, L. (*fuscicostellus*) Neb. Bull. Agr., p. 262.

a. *hemiochrellus* Zell.

Habitat. Tex.

1877 Zeller. Ex. Microlep., 49.

1878 Butler. Ill. Lep. Het., II., p. 51.

1880 Grote. Can. Ent., XII., p. 79.

Crambus myellus Hbn.

Habitat. Me., Can., Nova Scotia.

1863 Walker. (*latiradiellus*) Brit. Mus. Cat., XXVII., p. 159.

1877 Grote. (*interruptus*) Can. Ent. IX, p. 101.

1880 Grote. (*interruptus*) Can. Ent. XII, p. 15 and 78.

Crambus occidentalis Grt.

Habitat. San Francisco, Cal., Mendocino.

1880 Grote. (Orig. Des.) Can. Ent., XII., p. 16 and 77.

1881 Grote. Can. Ent., XIII., p. 66.

Crambus offectalis Hulst.

Habitat. Cal.

1886 Hulst. (Orig. Des.) Trans. Am. Ent. Soc., XIII., p. 166.

Crambus oregonicus Grt.

1880 Grote. (Orig. Des.) Can. Ent., XII., p. 17 and 78.

1880 Grote. N. Am. Ent., p. 68, Fig. 9, Pl. V.

Crambus pectinifer Zell.

Habitat. Tex.

1877 Zeller. Exot. Microlep., p. 51, Pl. I, Fig. 20, a. b.

1878 Butler. Ill. Lep. Het., II., p. 53, Fig. 20, a.b.

1880 Grote. Can. Ent., XII., p. 79.

Crambus pexellus Zell.

Habitat. Tex., Col.

1863 Zeller. (Orig. Des.) Mon., p. 48.

1880 Grote. Can. Ent., XII., p. 79.

Crambus plejadellus Zinck.

Habitat. Mass., N. Y., Ga.

1821 Zincken. (Orig. Des.) Germ. Mag., IV., p. 251.

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1887 Fernald. (*bonusculalis* Hulst.) Ent. Am., III., p. 22.

Crambus præfectellus Zinck.

Habitat. Mass., N. Y., N. J., Tex., Col., Can.

1821 Zincken. (Orig. Des.) Germ. Mag., IV., 249.

1860 Clemens. (*involutellus*) Proc. Ass. Nat. Sci. Phil., p. 203.

1863 Zeller. Mon., p. 18 ; (*pulchellus*) l. c.

1872 Zeller. Abhand. k. k. z-b. Gesellschaft, Vienna.

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Crambus repandus Grt.

Habitat. Col.

1880 Grote. (Orig. Des.) Can. Ent. XII., p. 79.

Crambus ruricolellus Zell.

Habitat. Me., N. H., N. Y., Pa., O., Ill., Can., London, Ont.

1863 Zeller. (Orig. Des.) Mon., p. 40.

1880 Grote. Can. Ent., XII., p. 79.

1887 Saunders. Can. Ent., XIX., p. 26.

Crambus satrapellus Zinck.

Habitat. Fla., Ga.

1821 Zincken. (Orig. Des.) Germ. Mag., IV., p. 247.

1863 Walker. (*aculeilellus*) Brit. Mus. Cat., XXVII., p. 158; (*elegantellus*) l. c.

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1870 Robinson. Ann. Lyc. Nat. Hist. N.Y., IX., p. 315 & 316.

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Crambus teterrellus Zinck.

Habitat. N. Y O., Pa., Va., N. C., Ga., Fla., Tex., Mo.

1821 Zincken. (Orig. Des.) Germ. Mag., IV., p. 251.

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Crambus topiarius Zell.

Habitat. Me., Mass., Ill., N. C., Sierra Nev., Cal., Brit. Am., St. John, New Brunswick.

1866 Zeller. (Orig. Des.) Stett. Ent. Zeit., 155, taf. 1, fig. 14.

1880 Grote. Can. Ent., XII., p. 17 and 78.

1882 Grote. Papilio, II., p. 74.

1886 Moffat. Can. Ent., XVIII., p. 31.
1887 Saunders Can. Ent., XIX., p. 26.

Crambus trichostomus Christ.

Habitat. Lab.

1858 Christ. (Orig. Des.) Ent. Zeit., 313; W. E. M., 379.
1880 Grote. Can. Ent., XII., p. 78.

Crambus turbatellus Walk.

Habitat. Va., Pa., O., Ill., Can.

1863 Walker. (Orig. Des.) Brit. Mus. Cat., No. 27.
1863 Zeller. (*bipunctellus*) Mon., p. 23.
1870 Robinson. (*bipunctellus*) Ann. Lyc. Nat. Hist. N.Y., IX., p. 315.
1880 Grote. (*bipunctellus*) Can. Ent., XII., p. 78.

Crambus undatus Grt.

Habitat. Cal.

1881 Grote. (Orig. Des.) Can. Ent., XIII., p. 66.

Crambus unistriatellus Pack.

Habitat. Me., N.H., N.Y.,Pa.,Minn.,Caribou Island,Cal.,Lab.

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1880 Grote. (*exesus*) Can. Ent., XII., p. 17 and 78.
1880 Grote. (*exesus*) N. Am. Ent., I., p. 68, Pl. 5. fig. 7.

Crambus vulgivagellus Clem.

Habitat. Me., Mass., N. Y., N. J., Pa., N. C., O., Ill., Tex., Cal., Vancouver's Is., Hamilton, Ont., Nova Scotia.

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1863 Walker. (*aurifimbrialis*) Brit. Mus. Cat.,No. 27, p. 157.
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Crambus zeellus Fern.

Habitat. Me., Mass., N. Y., Pa., W. Va., Ill., Mo., Cal.

1885 Fernald. (Orig. Des.) Can. Ent., XVII., p. 55.
1885 Forbes. Ill.Crop. Rept., p. 38 ; id. Rept. Ill. St. Bd. Agr., p. 48 ; id. Ill. Rept. on Ins., p. 12.
1886 Forbes. Can. Ent., XVII. ; id. Miss. Essays on Economic Ent., p. 10.
1886 Hulst. (*refotalis*) Trans. Am. Ent. Soc., XIII., p. 166.
1887 Fernald.=(*refotalis* Hulst) Ent., Am., III., p. 22.

EXPLANATION OF PLATES.

The lettering is uniform throughout.

Fig. 1. *C. luteolellus.*
Fig. 2. *C. caliginosellus.*
Fig. 3. *C. interminellus.*
Fig. 4. *C. hulstellus.*
Fig. 5. *C. mutabilis.*
Fig. 6. *C. decorellus.*
Fig. 7. *C. teterrellus.*
Fig. 8. *C. ruricolellus.*
Fig. 9. *C. vulgivagellus.*
Fig. 10. *C. unistriatellus.*
Fig. 11. *C. leachellus.*
Fig. 12. *C. hastiferellus.*
Fig. 13. *C. præfectellus.*
Fig. 14. *C. giradellus.*
Fig. 15. *C. elegans.*
Fig. 16. *C. turbatellus.*
Fig. 17. *C. extorralis.*
Fig. 18. *C. innotatellus.*
Fig. 19. *C. topiarius.*
Fig. 20. *C. albellus.*
Fig. 22. *C. agitatellus.*
Fig. 23. *C. minimellus.*
Fig. 24. *C. alboclavellus.*
Fig. 25. *C. floridus.*
Fig. 26. *C. laqueatellus.*
Fig. 27. *C. satrapellus.*

The significance of the letters upon the anatomical plates are as follows: *a*, antennæ; *a. s.*, accessory spine; *c. p.*,chitinous process; *g*, genital plate (female); *h*, harpe; *l*, lower limb; *m.m*, members of scaphium; *m. p.*, maxillary palpi; *p*, labial palpi; *pn.*, penis; *s*, scaphium; *v*, valve; *vg.*, vagina; *u*, uncus.

In Fig 16 the ventral aspect of the harpes and the dorsal aspect of the valves are represented; in figures 2, 10, 11, 12, 13 and 20 the mesal aspect of the right clasps are represented; in the others it is the mesal aspect of the left clasps.

PLATE I.

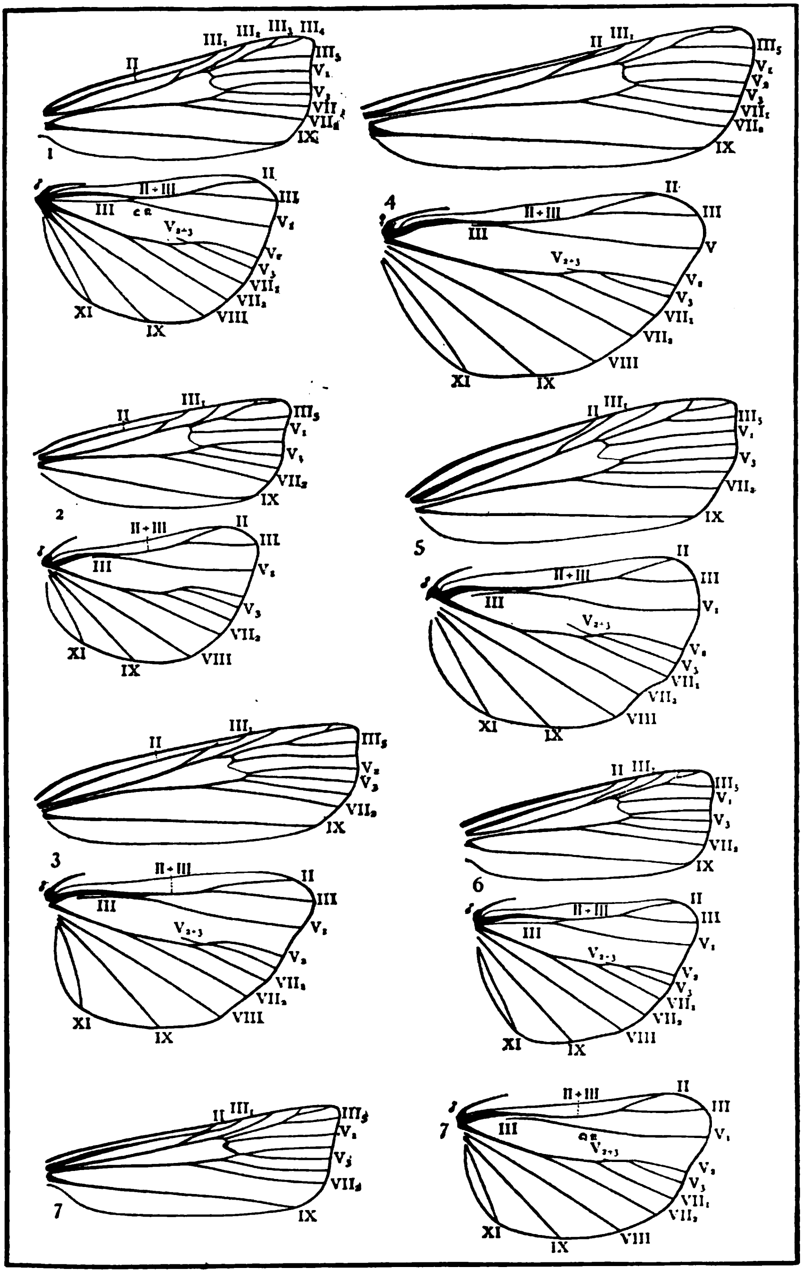

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PLATE II.

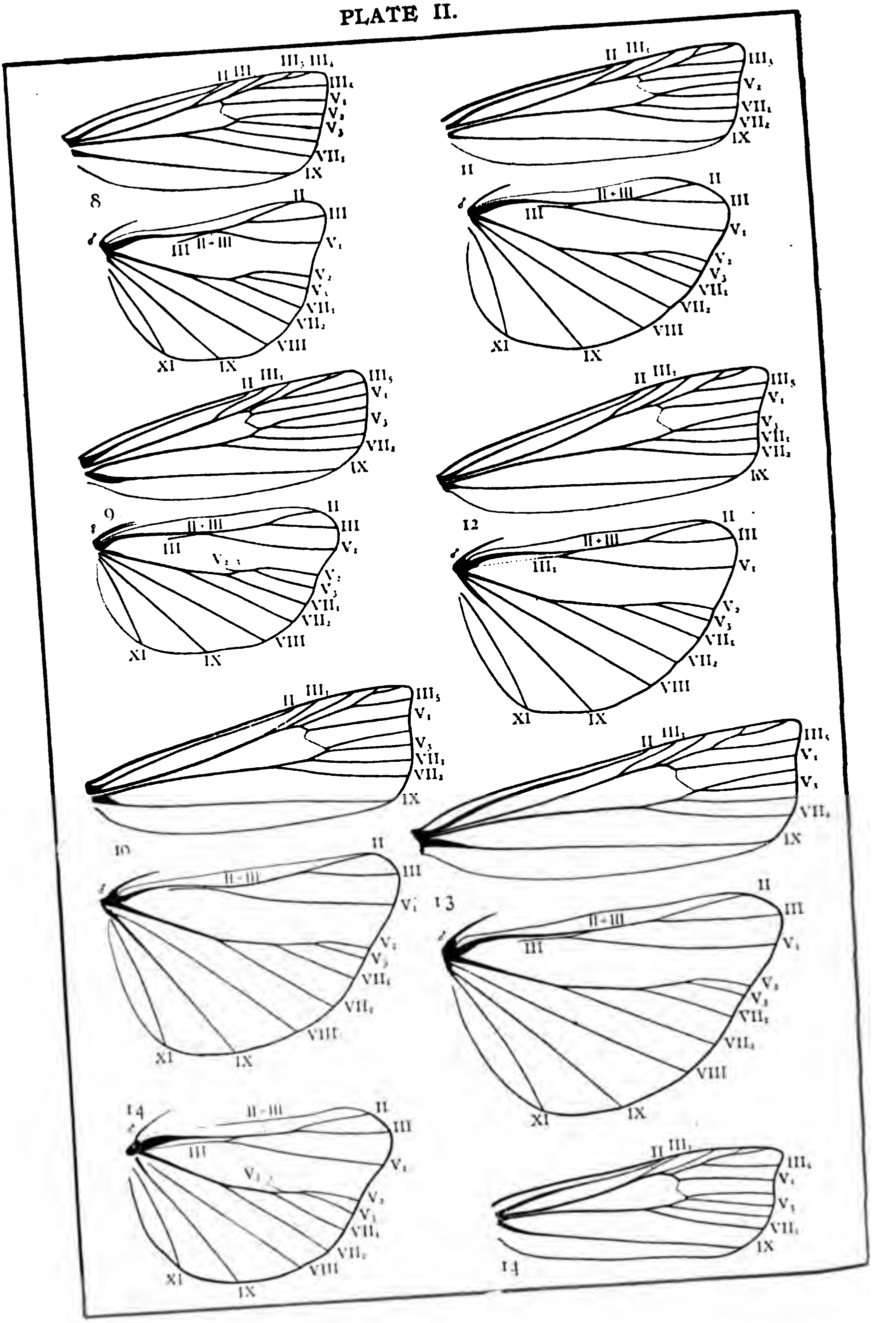
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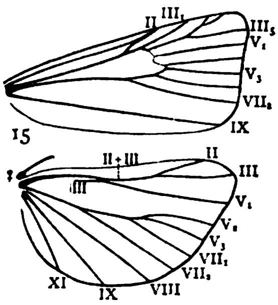
PLATE III.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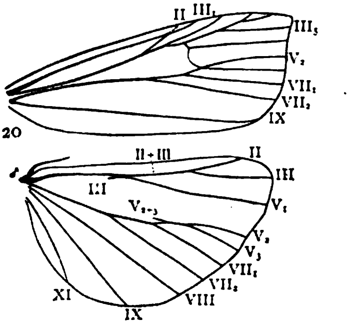
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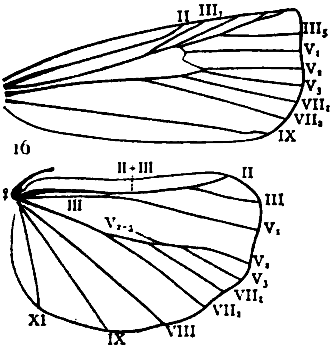
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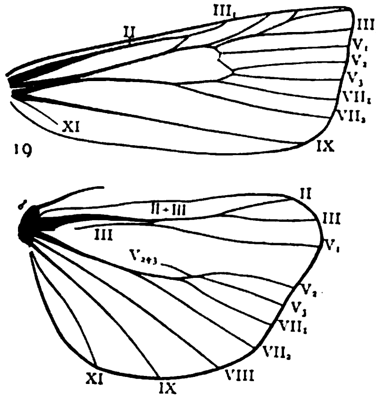
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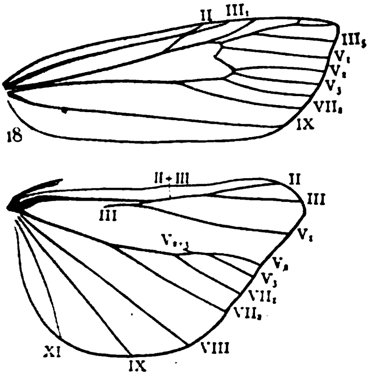
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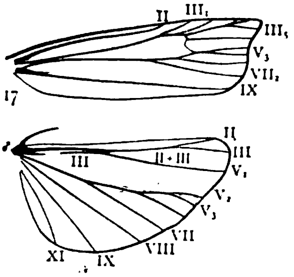
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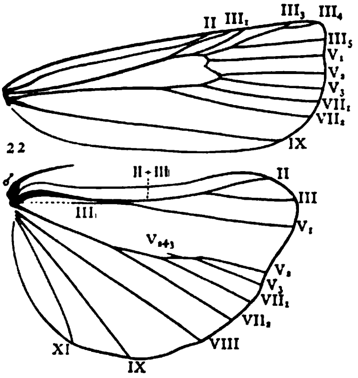

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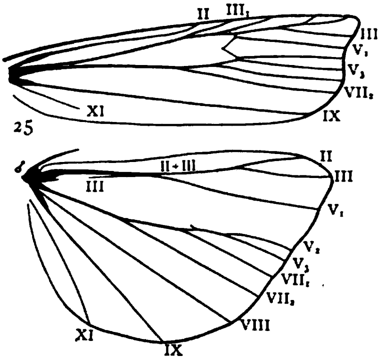

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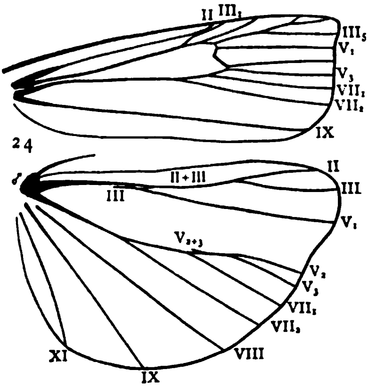

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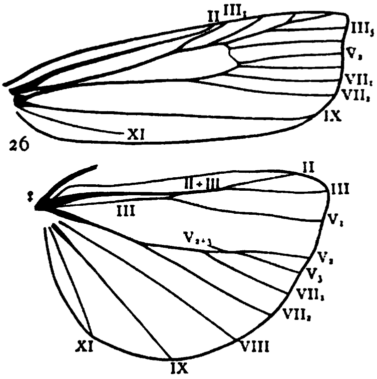

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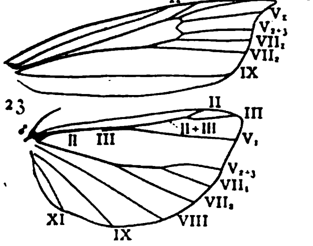

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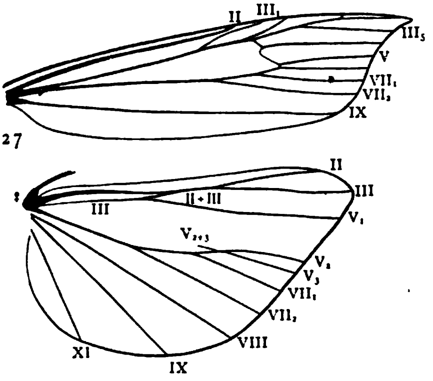

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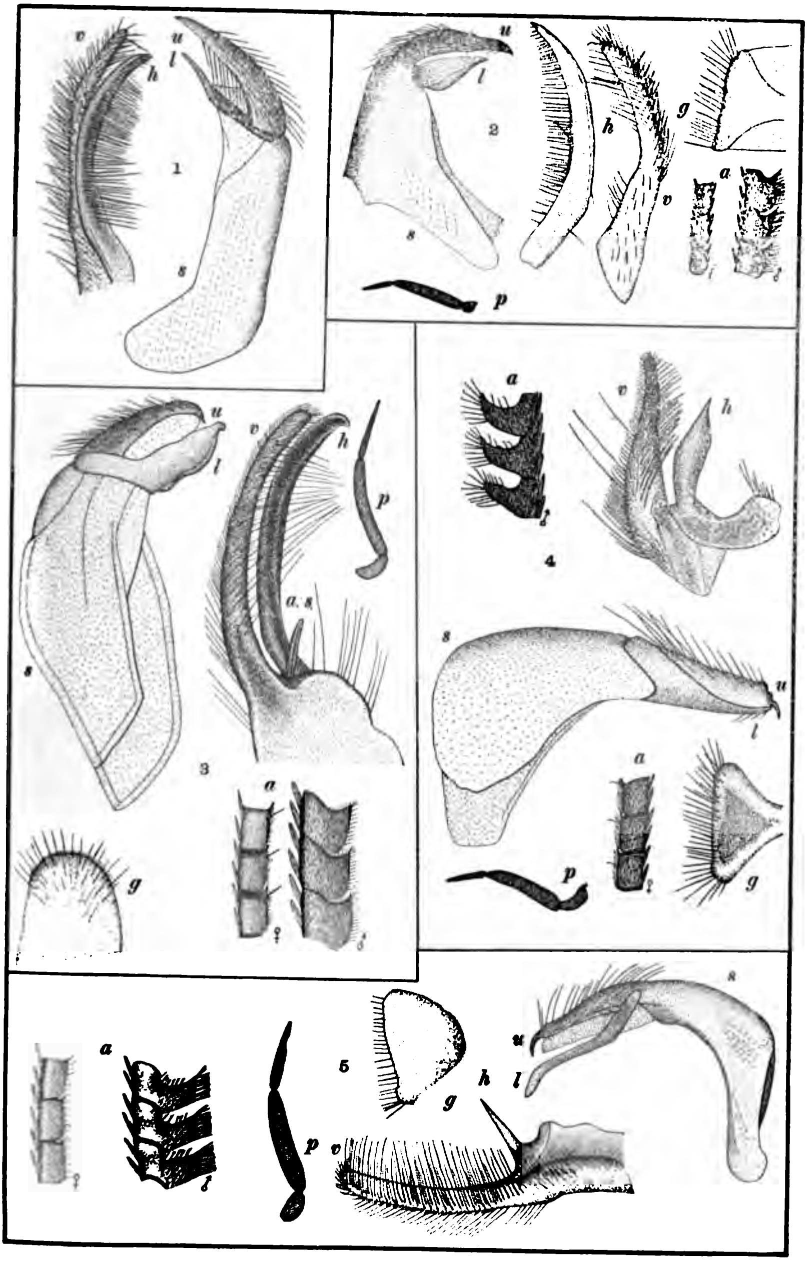

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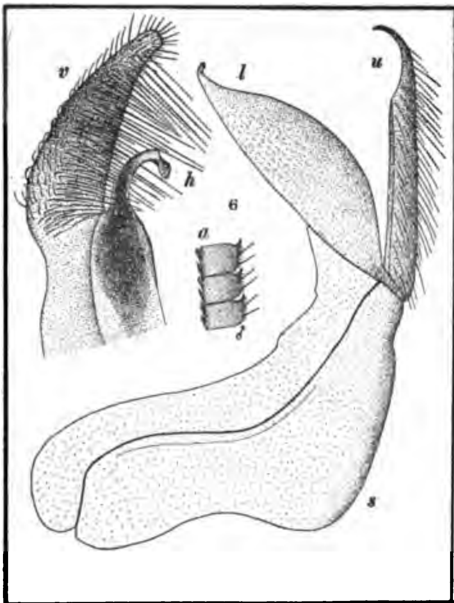

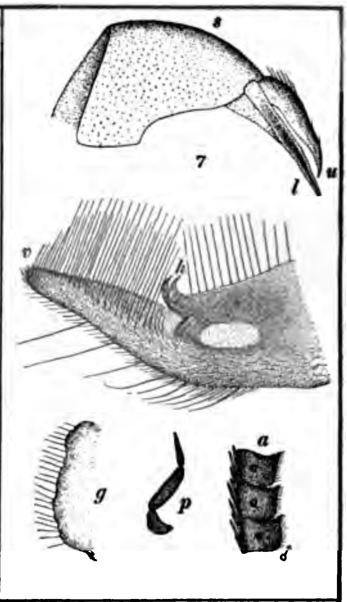

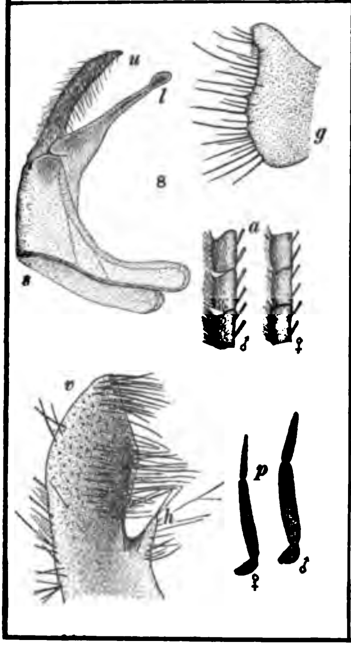

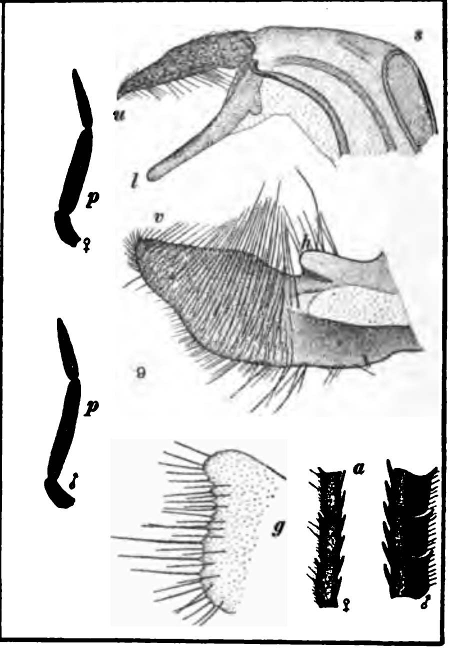

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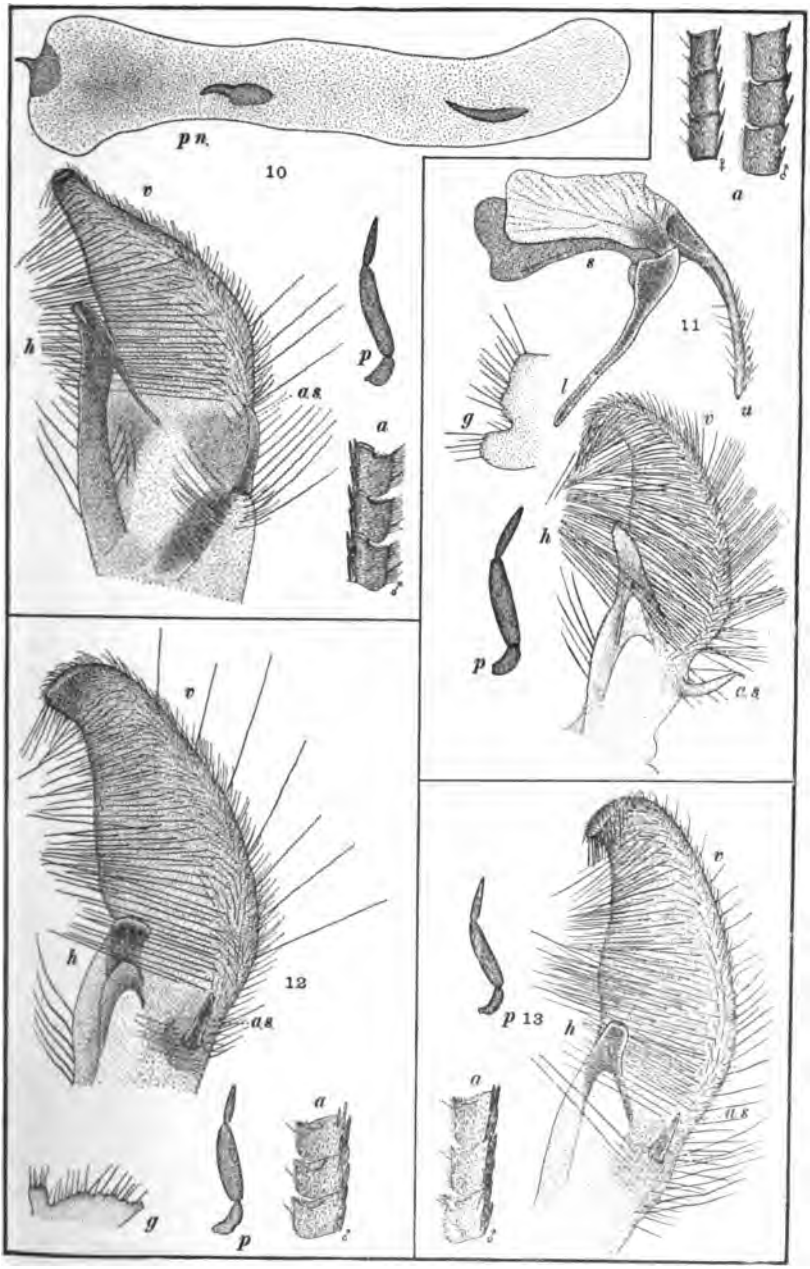

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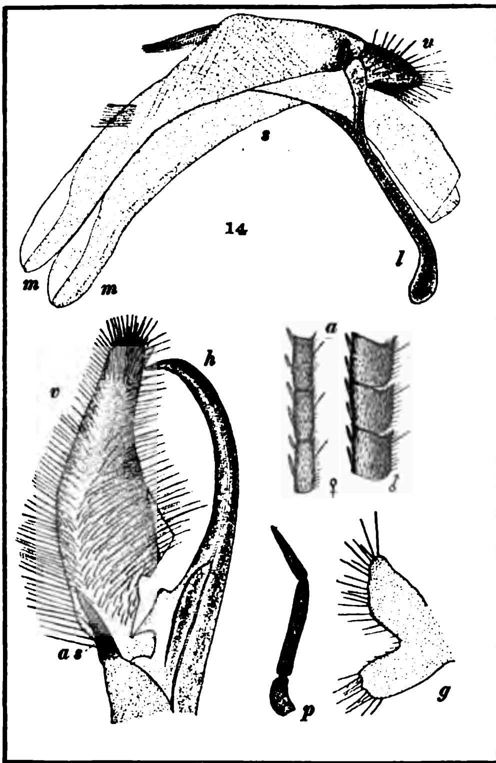

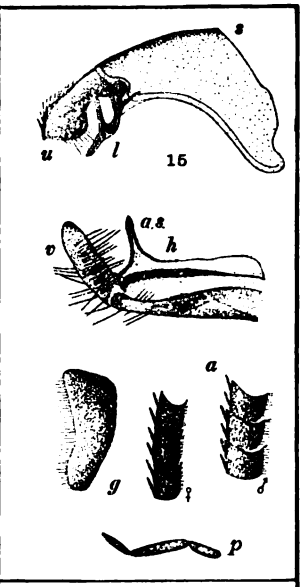

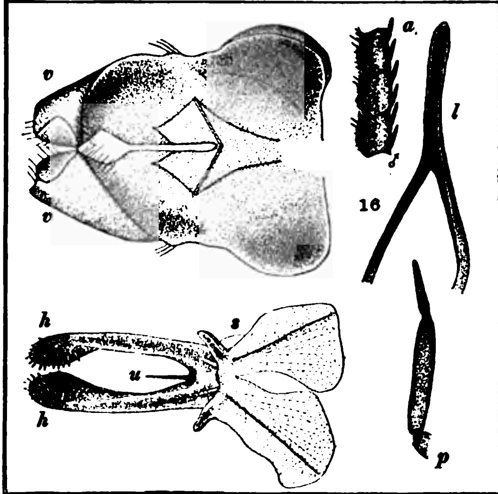

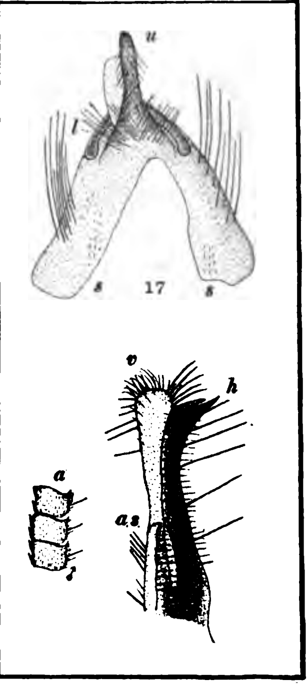

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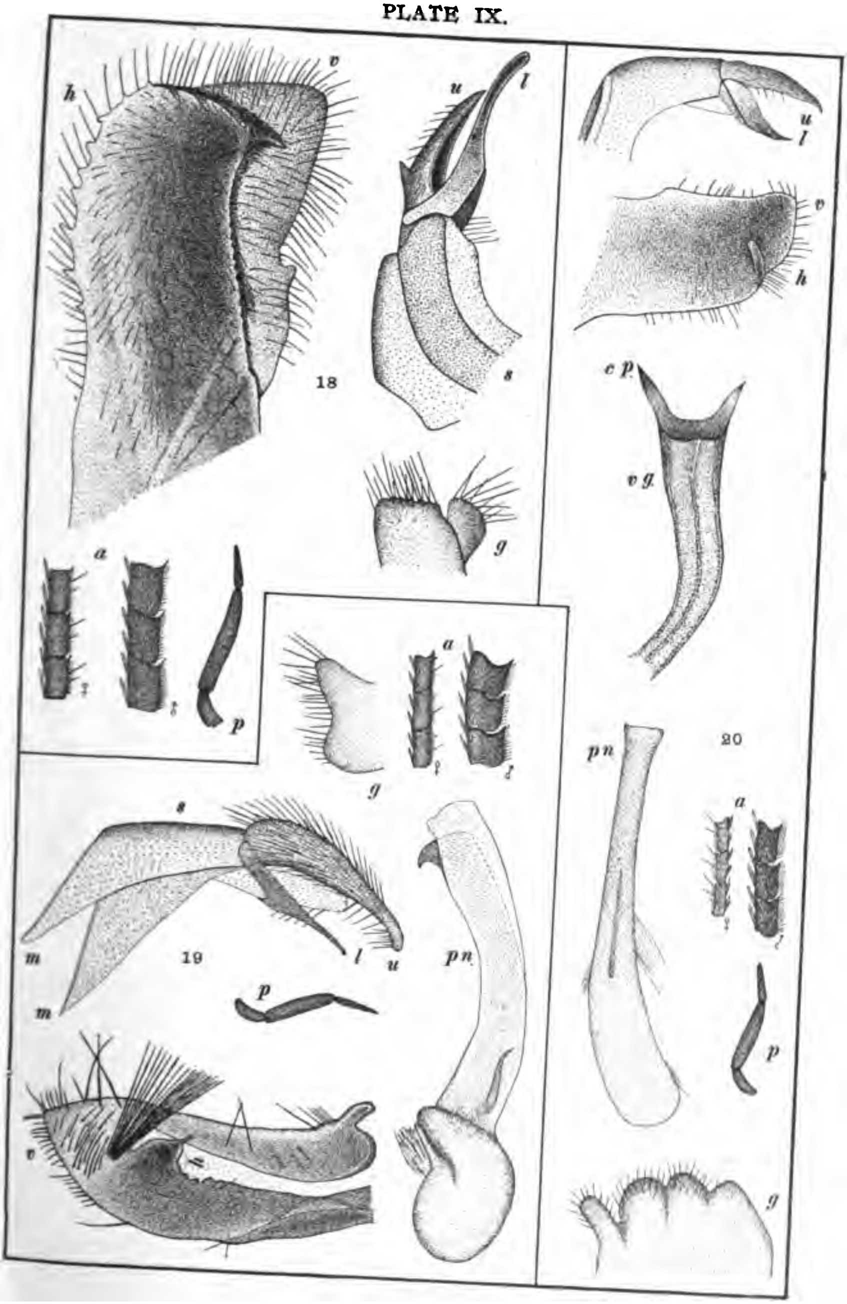

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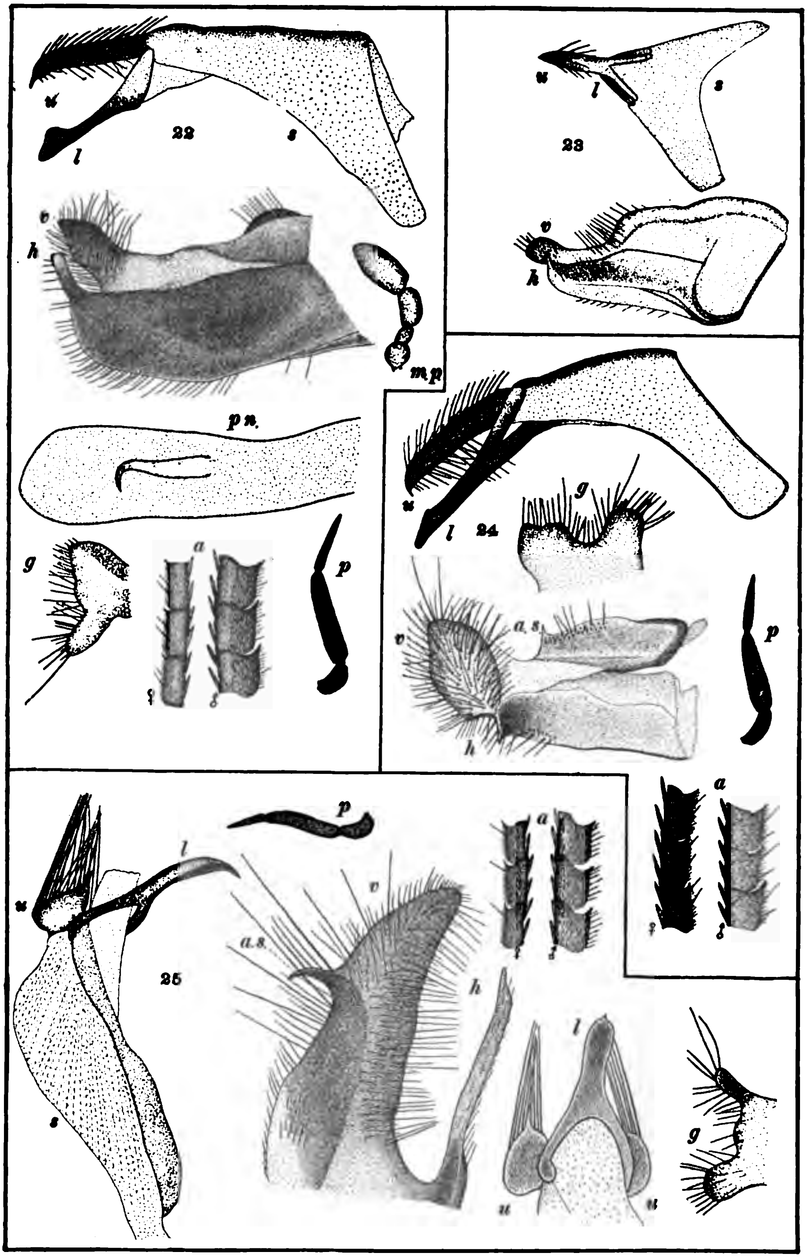

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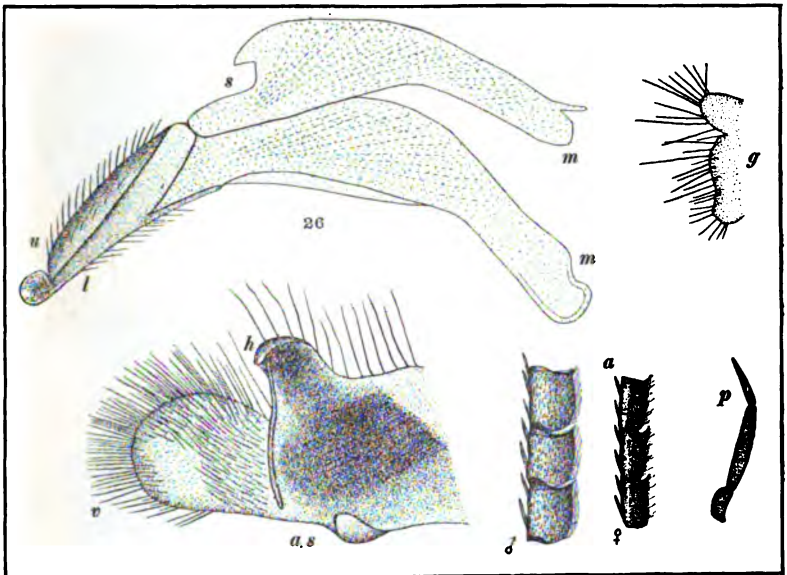

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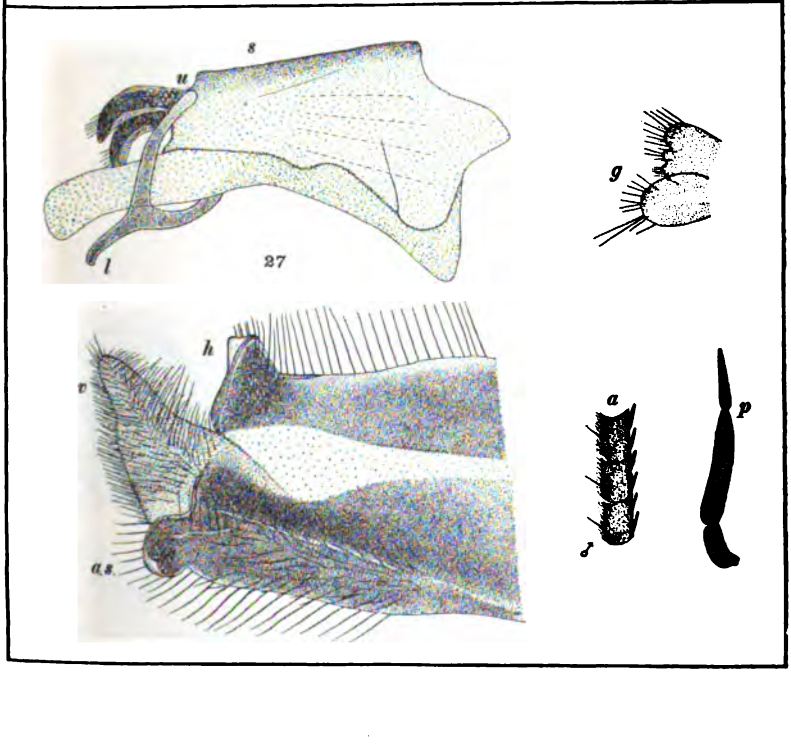

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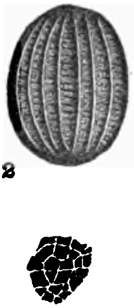
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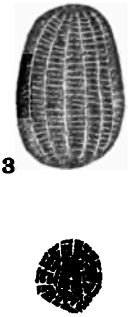
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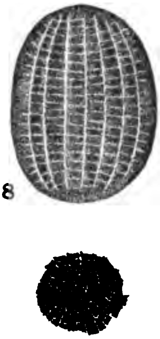
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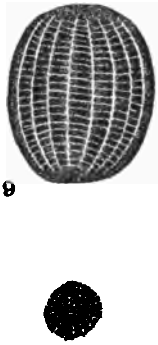
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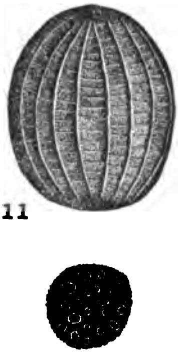
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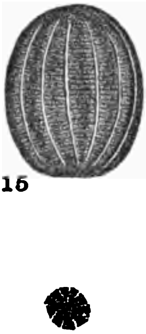
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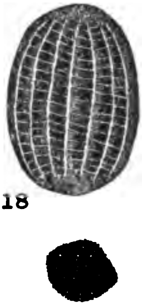
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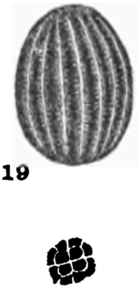
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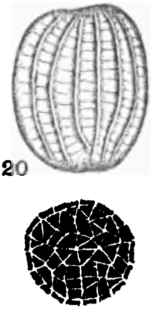
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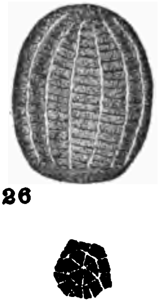
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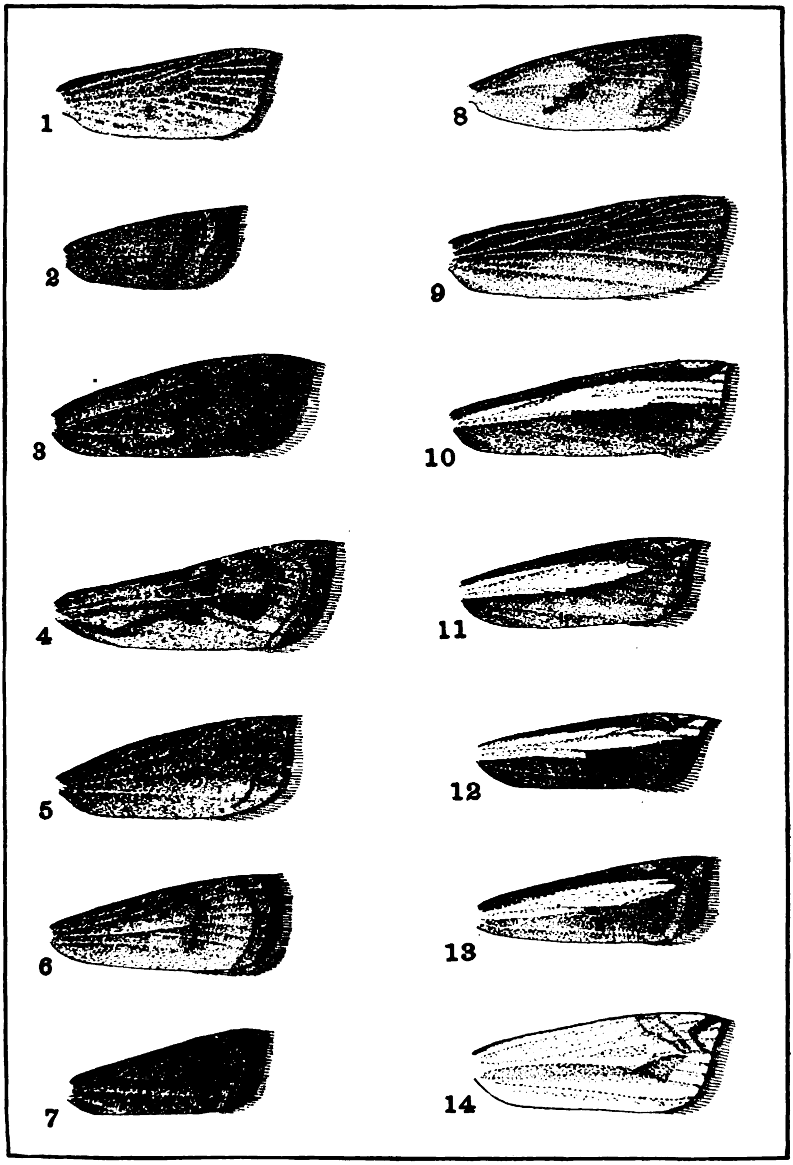

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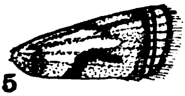
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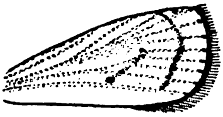
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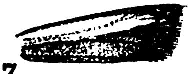
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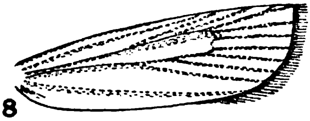
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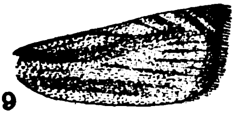
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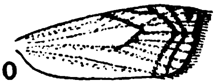
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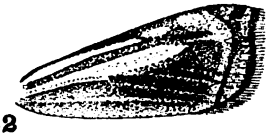
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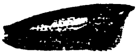
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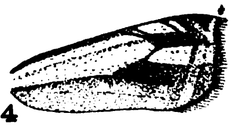
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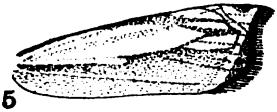
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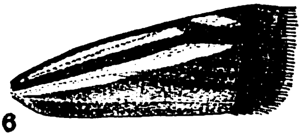
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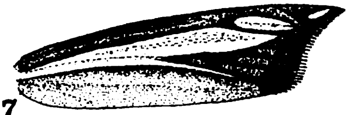
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Bulletin 65. **April, 1894.**

Cornell University Agricultural Experiment Station.

VETERINARY DIVISION.

TUBERCULOSIS

IN RELATION TO

Animal Industry and Public Health.

—BY—

JAMES LAW.

PUBLISHED BY THE UNIVERSITY,
ITHACA, N. Y.
1894.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.

TUBERCULOSIS IN RELATION TO ANIMAL INDUSTRY AND PUBLIC HEALTH.

ITS PREVALENCE AND RELATIVE IMPORTANCE.

Tuberculosis is so extensively prevalent and proves such a veritable scourge throughout the civilized world that no disease is so deserving of close and accurate study, or of the enforcement of effective measures for its suppression. Cholera, yellow fever and small pox, which occasionally invade our territory, creating universal terror and dismay, claim but few victims as compared with this ever-present, universally devastating plague. These other plagues are quick, severe and fatal, it is true, but for this very reason they can be promptly recognized, and checked and even stamped out, whereas tuberculosis is equivocal and underhand in its method, slow and uncertain in its progress, and on this account escapes recognition and proves by far the most deadly of any single disease attacking the human family. The average ratio of deaths from tuberculosis to the total mortality is 14 per cent., or one death in every eight, while under special conditions it rises to one in three, as in the Marquesas Islands, or even one in two, as in some of our Indian reservations. Tuberculosis may be classed with "the pestilence that walketh in darkness, " while the the three other diseases named are like " the destruction that wasteth at noonday." But the deaths from tuberculosis being constant and uniform, people accept them as inevitable and fold their idle hands with true Mohamedan fatalism instead of boldly exposing the hidden deathtrap, and cutting short its destructive work.

If the 5,490 deaths from tuberculosis which occur every year in the city of New York could be brought together in an epidemic lasting but one week, no small pox, cholera nor yellow fever scare would approach the panic which would thus be created, for when did all three diseases together create such mortality in this city? Nay, if we take the whole civilized world and compare with the tuberculosis mortality, all the accumulated deaths from war, famine, plague, cholera, yellow fever and small pox we find that the latter are comparatively very insignificant. Yet tuberculosis like every germ disease is absolutely preventible, and is allowed to continue its career of death only because of reprehensible ignorance and criminal indifference.

ITS PREVALENCE IN THE LOWER ANIMALS.

Few if any diseases maintain a sway over a more numerous genera of animals than tuberculosis. Among the domesticated animals cattle are perhaps the most susceptible, but chickens, guineapigs, rabbits, swine and goats become victims almost if not quite as easily. Some have thought that dogs, cats, sheep and horses are exempt, but when inoculated with tuberculous material these all contract the affection readily enough. The fact that they do not contract it in such numbers in the usual way is probably due in part to the greater amount of outdoor life which they enjoy, also to the fact that they have more exercise which secures for them a better developed and higher conditioned muscular system, and a full stock of constitutional vigor. After making all these allowances, however, it must be granted that these four classes of animals enjoy a native intolerance to this disease to which the first six classes mentioned are comparative strangers.

Among the less domesticated animals which contract tuberculosis may be named caged apes, lions, kangaroos, deer, elk, gazelle, antelope, birds, and in addition the rats, mice and other vermin of our houses and barns. All must, therefore, be considered as possible bearers and disseminators of the infection and no such animal (indeed, scarcely any animal) can be left out of account in any systematic attempt to root out the disease. Some, however, are justly held to contribute more than others to the maintenance of the affection, and in this sense, in addition to man himself, we must consider as preëminently bearers of this disease cattle, fowls and pigs.

Accurate statistics are wanting to give the rates of tuberculous animals in our herds, as we have no systematic professional inspection of live animals and of those killed for human food. Even in the large cities of Europe when such inspections are obligatory, in the case of carcasses, the data given are so variable as to suggest the acceptance of different standards in the various cities and countries. Thus tuberculous cattle are said to number: In Bavaria 0.225 per cent. (Goring), in Augsburg 0.26 per cent. (Adam), in Baden 0.2 per cent. (Lydtin), in France 0.5 per cent. (Arloing), in Belgium 0.4 per cent. (Van Hertsen), in Paris 6 per cent. (Friedberger and Fröhner), in Holland 20 per cent. (Schmidt), in Pommerania and Bomberg 50 per cent. (Schanz, Albrecht), at Hildesheim, Hanover, 60 to 70 per cent. (Haarstick), in Leipsic 20 per cent. (Rieck), in Edinburgh 26 per cent. (Cope, McFadyean). American figures given by the Bureau of Animal Industry are for Baltimore (mostly cows) 2.5 to 3.5 per cent. and for the packing centers (among 2,273,547 mostly steers) 0.02 per cent. It must be noted that the data from Baltimore is somewhat too favorable for city cows, as the cows were largely from infected dairies, where the more rapidly fatal lung plague carried off many before time had been allowed for the development of tuberculosis, and as the vacancies were speedily filled by fresh cows from country districts, the results give the ratio for country herds rather than the normal proportion for the city. The splendid showing for the steers must also be qualified by the remark that the fat and apparently healthy are alone sent to the large distant market while the unthrifty are held back lest they should spoil the sale.

Steers further largely escape on account of their out-door life with less opportunity for infection, and because they are, as a rule, killed at three years old and under, and tuberculosis becomes more and more prevalent with the advancing age of the stock. In a large aggregate number of German abattoirs, cows suffered in ratio of 6.9 per cent., oxen 3.6 per cent., bulls 2.6 per cent., and calves and yearlings 1 per cent. In Leipsic, tuberculous cows were 26 per cent., oxen 19.5 per cent., bulls 15.4 per cent., and calves 9.3 per cent.

In infected breeding and dairy herds in New York, consisting largely of mature cows I have found a maximum of 98 per cent. and a minimum of 5 per cent. Again in healthy country districts I have found hundreds of cows in adjoining herds without a trace of tuberculosis among them.

TUBERCULOSIS CONTAGIOUS.

In the middle ages tuberculosis in animals was recognized as contagious and laws were made against the use of the affected carcasses as human food, which remain in force in Italy and Spain to the present day. In the 16th century the disease was confounded with syphilis and at the end of the 18th century with glanders, blunders which, however untenable, show the strong conviction that the malady was contagious. The propagation by contagion in herd was recorded in Germany by Ruhling (1774), and Krunitz (1787), and more recently by Spinola, Zannger and others. In France the same is claimed by Fromage, Huzard, Lafosse, Dupont, and Cruzel.

It must be allowed, however, that in the first half of the present century, the manifest tendency of the disease to run in families, and to develop under special unwholesome conditions of life, served to weaken the belief in contagion, and in Central and Western Europe such belief had become practically extinct among medical men, when their attention was recalled to the subject by the successful inoculations of tuberculosis on rabbits and guineapigs, by Villemin, in 1865. The subject was taken up on all sides by incredulous experimenters and for a time a keen polemic warfare raged, but slowly the stern logic of constantly accumulating and unanswerable facts compelled all candid observers to accept the doctrine of contagion.

THE GERM. BACILLUS TUBERCULOSIS.

An even fuller demonstration came in 1882, when Robert Koch, of Berlin, demonstrated the existence of the tubercle bacillus, and showed that the disease could be produced with equal certainty by inoculating with the substance of a tubercle from the ox's lung, or with a pure culture of the germ grown on peptonized gelatine, apart from the living body. Before publishing his discovery Koch demonstrated the presence of the bacillus in the expectoration or tubercle of over 100 cases of consumption, and had successfully inoculated 472 subjects—guineapigs, rabbits, mice, rats, and cats, besides dogs, pigeons and chickens. The following are some of the characteristics of this germ :

Form.—A delicate rod with rounded ends, 1.5 to 3.5 micromillimeter in length (about 1-2500th of an inch). They occur singly, or in pairs or chains of three or four connected end to end. When cultivated on blood-serum the groups tend to form elongated rope-like colonies, having a waving or serpentine outline.

Staining.—It is characteristic of this baccillus that it absorbs coloring matters very slowly and once stained retains its color with great tenacity. This enables the microscopist to distinguish this amid a mass of other microbes. The opaque particles in sputum or a section of the tubercle is stained by prolonged exposure to a warm alkaline solution of an aniline pigment; it is then bleached by a solution of nitric acid (1:3); it is then washed and slightly stained with a color which will contrast with the first; finally it is washed, mounted and examined under the microscope. The rod-like bacillus tuberculosis appears stained with the first color while the other bacteria, if any, are stained with the second.

Biology, Life-history.—The bacillus tuberculosis lives mainly as a parasite in the animal body, but may be cultivated on the ordinary culture media containing 5 per cent. of glycerine and makes the best growth at 100° to 102° Fah. A temperature of 158° Fah. for ten minutes is fatal to it (Yersin). Unlike many bacilli this shows no spontaneous movement at any stage of its growth. Its development is slow in any medium, the earliest signs of growth being visible only after ten or fourteen days.

Vitality.—As it has great power of resistance to the entrance of coloring fluids, so this germ can hold its own for a length of time against destructive agencies. It retains its vitality and infecting power for nine to ten months in dried expectoration (Koch, Schill, Fischer, De Thoma). In tuberculous cow's lung, dried and pulverized, it infected Guinea pigs after 102 days. In putrid matter it infected after 43 days (Schill, Fischer) or 102 days (Cadeac, Malet). It is not destroyed by gastric juice (Baumgarten, Fischer, Falk).

In sputum it perishes in 20 hours in a 3 per cent. solution of carbolic acid in a saturated aqueous solution of salicylic acid or in saturated aniline water (Schill, Fischer); in five minutes by iodoform ether; in ten minutes in sulphuric ether or mercuric chloride (1:1000); in three hours in thymol. It dies in a few hours in direct sunlight, and in five to seven days in diffuse daylight (Koch). In an ordinary room it gradually weakens but remains virulent for at least 2½ months (Sawiskey).

INDESTRUCTIBILITY OF THE GERM.

Drying and heating—The substance of a tubercle, like expectoration, may be dried up and reduced to powder without lowering its virulence provided too much heat has not been employed in the drying. Although an absolute heat of 158° Fah. for 15 minutes is fatal to the germ yet in virulent masses, as in meat, it is difficult to determine the actual temperature at all points and tests are therefore often misleading. Thus Toussaint found that broiled steak, the interior of which by his tests had reached 163° to 176° Fah. was still infecting. Martin heated tuberculous matter in sealed tubes to 212° Fah. and found that even then some germs would exceptionally escape. Chauvean and Arloing found that nothing survived half an hour of the boiling temperature and Galtier found that 162° Fah., which coagulates albumen, sterilized completely if kept up for a sufficient length of time. If in cooking meat, the blood (albumen) is not coagulated but oozes out as a red fluid the temperature has not been enough to ensure the death of the bacillus. Where there is a risk of tuberculosis therefore *rare* steaks must be refused.

In milk as in meat heat is effective but at 162° Fah. the continued albumen is coagulated, the liquid acquires the boiled flavor, a tendency to constipate, and a diminution of its digestibility and nutritive qualities. In sterilizing this liquid, therefore, for infants and invalids, it is better to keep the temperature at 158° Fah. for a longer period, say half to one hour continuously.

Drying of the tuberculous matter in doors or in the shade, and apart from the above temperature, and its inhalation as fine dust is one of the most common causes of tuberculosis. In one store with a tuberculous clerk the dust raised in sweeping out the store infected clerk after clerk, and a similar rising of the virus in dust is a cause of infection in dwelling houses, stores, barns, barnyards, stockyards, and railroad cars. It is now allowed that the infecting matter dried on the handkerchief, and shaken out on the air is one of the most prolific sources of infection. So in animals, a manger smeared with the discharge of a diseased animal, retains the virus in an infecting state and infects the next susceptible animal fed from it. Hence long before the days of Koch and his discovery of the bacillus, the infection of animal after animal which occupied the same stall in succession had convinced observant stock owners and veterinarians of the contagion in tubercle.

Survival in Water and Moist Earth.—Galtier found that the bacillus tuberculosis was preserved indefinitely in springs, ponds and wells at all ordinary temperatures. Hence the danger of common drinking troughs, of streams that have run past infected herds, or the places where their manure has been put and of soil that have received the manure or carcasses of the deceased. The danger from soils is less from dust blown from the surface and which has been presumably devitalized by prolonged sunlight, than from the earth that is pulled up attached to the roots of the turnips, beets and carrots or to tubers like potatoes. Grain crops may therefore be grown with greater safely on infected soils, than can root crops.

Freezing.—The germ survives a freezing temperature. Galtier kept tuberculous matter at different times in a frozen state for four and five days respectively and found it still infecting. Neither the winter's frost, therefore, nor the usual alterations of temperature in the soil can be trusted to speedily disinfect it.

Putrefaction is not fatal to the germ (Cornil, Babes, Mallassez, Vignal, Galtier, etc.).

Heavy salting of meats has been thought to be fatal to the germ in one month. After fifteen days in salt the germ failed to kill rabbits but still killed the Guinea pig, whereas after thirty days it killed neither (Galtier). In salting, however, the meat is impregnated unequally in different parts of the same mass, and therefore, as in the case of a temporary heating, this cannot be relied on as a safe measure of disinfection.

The comparative indestructibility of the germ under any of these conditions, shows that the slow absorption of pigments by the bacillus, is significant of an equally tardy penetration by other hurtful agents, and of a corresponding power of resistance to ordinary disinfectant agents.

ACCESSORY CAUSES OF TUBERCULOSIS.

While all must to-day recognize that the one essential cause of tuberculosis is the bacillus, yet it is wrong to ignore the fact that many conditions of the animal system and its surroundings contribute to the propagation of the disease, or retard its progress.

While none of such accessory causes can generate tuberculosis in the absence of the bacillus, yet when that diseased seed is present, these conditions often serve to sway the balance toward its advancement and diffusion, or its restriction and suppression. A suitable soil and favorable climate is no less essential for the vigorous growth of the microscopic vegetable microbe, than for the Florida moss or the palm.

Among the most efficient accessory causes may be named:

a. Hereditary Predisposition.

Consumption runs in families and it has long been supposed that this was essentially a family—that is, a hereditary disease. But as a matter of fact it is extremely rare to find the offspring tuberculous at birth or before. In many thousands of pregnant tuberculous cows killed in the slaughter-houses of Europe 'not more than ten tuberculous calves have been found. To the same effect is the fact that in calves under a year old, born of cows, six per cent. and upwards of which prove tuberculous, the ratio of tuberculosis is often below one per thousand. In Saxony with the ratio of tuberculous cattle 16.5 per cent. that of tuberculous calves was only 2 per 1000. At Lyons out of 400,000 calves slaughtered only 5 were found tuberculosis and at Munich out of 400,000 but 2 tuberculous. Again in such calves the tubercle is found in a very large proportion of cases in the bowels and adjacent glands suggesting infection after birth through the milk, rather than in the liver and lungs which would have been its natural seat if conveyed before birth through the blood. Not a few of the obstinate and fatal bowel diseases of sucking children and calves are in reality tuberculosis of the bowels induced by the infected milk.

What runs in a family then is rarely hereditary disease:—it is in the great majority of cases only a hereditary susceptibility to the disease, tuberculosis. But it is none the less a fearful legacy, being often so potent that the disease attacks certain families as a matter of course, while other families can count on a practical immunity. In the human family this is notorious. In cattle it is no less remarkable. In the Burden herd of Jerseys in 1877, I made examinations, and condemned eleven animals, verifying my diagnoses by examinations after death, and found to my surprise that I had taken every representative of a given family, and left the pure bred members of the second family untouched. Both families had mingled freely in the pastures and yards, yet the second family furnished no tuberculous cases and remained sound from that time onward.

b. Close Buildings, Lack of Ventilation.

Air rendered impure by repeated breathing is so favorable to the propagation of tuberculosis that it has been looked upon as the sole cause (Macormac). Though now certain that this cannot produce tuberculosis at all in the absence of the germ, yet it is such a potent accessory cause when the bacillus also is present, that its importance cannot be too highly appreciated.

For the mild cases of tuberculosis in man life in the open air, day and night, in a genial climate with pure air affords one of the best grounds of hope of recovery or mitigation. In the Burden herd above referred to, animals condemned in the spring spent the summer at pasture, with a general appearance of perfect health, yet, when returned to the barns in the fall, they fell off so that soon some of them had to be helped to rise in the stall. All the world over city dairy cows are notorious for tuberculosis. In Europe where the country cattle are affected in a ratio of 1 to 2 per cent., those in the city dairies suffer to the extent of 6 to 20 per cent. and upward. Of our plains and prairie steers the government inspectors, at the abattoirs, condemned as tuberculous but 0.02 per cent., whereas of the city dairy cows, mostly recently from the country, they condemned 1.23 per cent. The ratio is 1 steer to 60 cows, a most striking showing in favor of an open air life.

c. Dark Stables.

Dark stables are usually dirty and ill-ventilated, and as such, lower the general health of the inmates and strongly predispose them to tuberculosis. The darkness, however, acts indirectly in depriving the tissues of the body of their due supply of air. The formation of green pigment (chlorophyll) in plants, and that of red pigment in the blood globules are alike due to the action of light. In darkness both disappear. But the red globules of the blood are the bearers of oxygen to all parts of the body, and if these globules are deficient the whole body is denied its due aeration. The final result is as if the air contained little oxygen, in other words, as in the case of a close building without any means of renewing the air.

d. Insufficient or Unwholesome Food. Overtaxing.

Lack of food, and indigestible, or innutritious food, agree in producing practical starvation and weakness with increased susceptibility to tuberculosis. Hence, this disease is the scourge of the half starved poor, and no less of the rich who abuse their digestive organs, and court chronic dyspepsia. So, too, in our dairy herds the stimulating ration-for-milk, the warm drinking water, and warm atmosphere, together with the enforced rest in the stalls for months at a time, and the clean, careful milking soliciting the gland to act to its extreme capacity, all tend to a lowering of the general health and an increased susceptibility. This sufficiently illustrates how the cow which has been made a milking machine, and which to this end must produce a calf every year, becomes dangerously susceptible to any tubercle bacillus to which it may be exposed. We have developed most valuable qualities at the expense of hardihood, and we must take the consequence. The argument is not that we should part with acquired powers which give the animal its high value, but that we should recognize the attendant dangers and rigorously exclude the tubercle germ.

e. Breeding too Young.

Breeding of immature animals is a most fruitful accessory cause of tuberculosis as the demands made upon the system for further growth, for the nourishment of the unborn offspring, and later for the nursing of the calf, or for the dairy yield, undermine the strength and vigor. In different families of that marvelous dairy cow, the Jersey, this has been carried to such an extent that discredit has been thrown upon the whole breed as one especially prone to tuberculosis.

f. Inbreeding. High-breeding.

Inbred families of cattle are proverbially subject to tuberculosis. This is due partly to a resulting constitutional weakness, which often shows itself in an increasing indisposition to breed to near relatives, though still fertile with strangers. More frequent ly, it depends on the intensifying and fixing of personal and family characters. The susceptibility to the germ being equally strong in both parents becomes intensified in their common offspring just as the beef or dairy characteristics are improved. Indeed, the qualities which make an animal valuable for the butcher or milkman are exactly such as favor tuberculosis. The germ of this disease lives by preference in the lymphatic system, either in the lymphatic glands or in the loose connective tissue forming the lymphatic networks leading to these glands. Now the breeds which are preëminent for early maturity, and rapid fattening, or for a high yield of milk are remarkable for their excess of connective tissue, as shown by the delicate mellow skin, and in the case of the Channel Island cattle by the unusually large lymphatic glands. This helps to explain why certain families of beef-making cattle have been virtually ruined by tuberculosis. Yet it would be equally wrong to abandon the improvement of our beef and of our milking breeds. The improvement already attained is essential to successful competition in the market, and prospective improvement will be no less essential in the future. The true and only real remedy is the extinction and exclusion of the bacillus of tubercle.

g. Ill Health.

All acute and chronic diseases leave the system weak, and with less power of resistance to other diseases. Above all we must fear long standing diseases which produce emaciation and weakness, fevers which interfere permanently with the blood-forming processes, diseases of the digestive organs, which hinder the requisite preparation and absorption of nutritive elements, and diseases of the lungs which form a raw or weakened surface on which the bacillus can grow without hindrance. Again the germ lives best in a slightly alkaline or neutral medium, and is weakened in the acid contents of the stomach during vigorous digestion. But in indigestion the contents may be too much lacking in acidity to prove hurtful to the germ, and the imperfectly digested morsels, enclosing the bacillus, may be passed on unchanged into the alkaline intestine, a field especially favorable to the development of tuberculosis. Again in the intervals between meals when the acid secretion is arrested, the bacillus in drinking water may easily pass through the sentinel stomach to develop in the intestines.

h. Chemical Poisons in the Tuberculous Body.

The soluble chemical poisons in meat and milk of consumptives will be noticed later as a potent cause alike of susceptibility to tuberculosis and of its more rapid progress when already in the system.

LESIONS AND SYMPTOMS OF TUBERCULOSIS.

Tuberculosis appears under two great types: the acute and the chronic, the first of which may run a fatal course of four to six weeks, while the second may last for many years. At the outset in the acute form, and for a great length of time in the chronic, the disease-process may be confined to one organ or to one region of the body and therefore the symptoms may vary exceedingly according to the particular organ attacked. In many chronic cases, with the tubercles confined to one organ or locality (lymphatic glands, liver, spleen, pancreas, etc.) the victim may be in good condition and no sign of disease may be recognized by the owner or even the veterinarian. In acute cases on the other hand and when the tubercles are generally diffused through the body, there is usually fever, wasting and emaciation in addition to the characteristic symptoms of disease in particular organs.

The lesions being caused by the colonization and local multiplication of the bacillus they tend to assume a rounded or nodular form, from which has been derived the name of tubercle. Such nodules may, however, be absent, the diseased product, being a diffuse infiltration and thickening of the affected part. The early nodule may vary in size from a millet seed up to a pea or more. It is at first red, congested and firm; soon it may become gray in the center though still red outside. With the grayish discoloration comes a gradually extending death of the mass (coagulation necrosis)and disintegration into a more or less soft cheesy looking material (caseation). In cattle and chickens this cheesy nodule tends to remain firm and it may even become gritty through impregnation with earthy salts (calcification). Exceptionally it will soften into a semi-liquid whitish debris, resembling an abcess, and this excessive softening is the usual course of tubercle in swine. In some cases however the tubercle does not break down into a dead cheesy mass but develops into firm fibrous rounded nodules hanging in clusters from the lungs, inside of the ribs, or skin, and known as pearl disease (perl-knoten), grapes, etc. This form is particularly common in cattle. In man may be found nearly all forms of the disease, the primary hard red congested nodule, the same with its grayish disintegrating centre, the firm caseated mass, the same further softened into a white or yellowish semi-liquid pus-like mass, and in addition an open unhealthy sore caused by the breaking down of the tuberculous growth on the skin (lupus), or intestine, etc. Similar tuberculous sores are found on the skin or mucous membrane (bowels, throat) of cattle and other animals. In all the many forms and seats of the disease the bacillus may be found in the affected parts, and the morbid discharges from the lungs, skin, open sores, etc.

SYMPTOMS IN CATTLE.

a. Tuberculosis of the lungs.—In the chronic cases which are by far the most common this may last for months and years unperceived; in acute cases it may prove fatal in a month.

In recent, slight, chronic cases there may be no other ground of suspicion than an occasional cough when the animal leaves the hot stable for the cold outer air, when it is suddenly raised in the stall, when it is run for a short distance, when it drinks cold water or eats dusty food. The cough is usually small, dry, wheezing, and may be repeated several times. When run or driven rapidly the animal proves short winded. Yet it may show as good spirits, as clear, full an eye, as smooth glossy a coat, as supple and mellow a skin, as good an appetite, as rich and abundant a flow of milk, and as much propensity to fatten as its healthy fellows. An accomplished diagnostician may detect altered sounds on percussion and anscultation of the chest, but from the difficulty introduced by the heavy muscular shoulder, the frequent variations in the size of the heart, the rumbling and crepitating sounds from stomach and bowels, which, according as they are full or empty, press forward and dimish the size of the lungs, and greatly mask or modify the results, even the able practitioner cannot be trusted to detect these, and the case fails to be recognized. There may be a flow from the nose in which bacilli should be detected by the microscope, but cattle have a habit of cleaning the nose with the pointed tongue, so that the virulent particles are difficult to secure, and when secured they prove to contain few bacilli so that a failure to find these would not be so reassuring as it would be in man. As a large proportion of cases of chronic tuberculosis of the lungs are of this kind the tuberculin test, to be noted below becomes practically indispensible.

When the lungs become more extensively involved symptoms are more distinct and reliable, and the animal usually falls off in condition, yet in many cases cattle in good condition are killed for beef and the lungs and ribs are found to be literally covered with clusters of fibrous tubercles (grapes). Usually in advanced cases the hair is dry, lustreless, and erect in patches, especially along the back. The skin is dry, powdery, and rigid without its customary mellow touch or mobility on the parts beneath. The eye is less prominent and brilliant, the breathing is more easily accelerated, the cough, more frequent and easily roused, is often gurgling or rattling and may cause a discharge from the nose of a whitish flocculent, sometimes gritty material in the flocculi bacilli may sometimes be found. The breath is heavy and mawkish. Pinching of the back at the shoulders or loins may cause wincing, groaning or cough, as may also pinching above the breastbone or striking the ribs with the fingers or fist. Percussion over the ribs reveals spots where there is a lack of resonance, apart from the solid masses of the heart, liver, spleen and stomach contents, and listening over these spots will detect that variety of morbid sounds familiar to the physician, the most prominent being rubbing, wheezing, creaking or fine crepetation, mucous rattling and various blowing sounds. A remarkable feature of tuberculosis distinguishing it from many other forms of lung consolidation attended by unnatural sounds, is the occurrence of such changes in patches with intervening spaces of sound lung. Ordinary inflammations more commonly attack one portion and spread from that as a center extending the solidification in one or all directions. Arrived at this stage the animal usually fails to make flesh satisfactorily on the best feeding, and milk is not only lessened but becomes poor, blue and watery.

The tubercles tend also to form more in other organs, notably the lymphatic glands and bowels, and digestion and assimilation being thus seriously interfered with emaciation advances more rapidly. This advance may be largely accounted for by the fact that the infecting expectorations brought up with the cough is largely swallowed to affect stomach and bowels. The animal has now diminished, and capricious appetite, irregular, infrequent, slow rumination and slight bloating after meals. The body temperature is more variable and more frequently high than in the slighter forms.

In the advance stages of lung tuberculosis everyone can recognize the consumptive animal. It is miserably poor and wastes visibly day by day, the dry coat of hair stands erect, the harsh scurfy skin clings tightly to the bones, the pale eyes are sunken in the sockets, tears run down the cheeks, a yellowish, granular, fœtid and often gritty discharges flow from the nose, the breathing is hurried and catching, the breathe fœtid. The cough is weak, painful and easily roused by pinching the back or breast or striking the ribs. Tapping the ribs with fingers or fist and applying the ear detect far more extensive changes including in many cases evidences of blowing into empty cavities (vomicæ) and loud gurgling. Temperature may vary from below normal to 107° Fahr.

In all such cases there is extension of the disease to distant organs and symptoms as given below complicate those of lung disease. To give means of diagnosis of tuberculosis from some diseases of the lungs which most resemble it in symptoms (lung worms, hydatids, actino-mycosis, lymphadenitis, etc.,) would unduly extend this article without corresponding advantage to my present class of readers.

Tuberculosis of stomach, bowels and mesenteric glands. In young animals living on milk, tuberculosis of the bowels and glands give rise to indigestion, fœtid diarrhœas, bloating, and finally enlargement of the superficial lymphatic glands and the affection of the lungs if the animal should survive long enough. In older cattle there is impaired irregular appetite and rumination, slight bloating after meals, a tendency to scour when liberally grain fed, costiveness alternating with scouring, colics, and usually a more pronounced wasting than with the lung disease. The oiled hand introduced into the last gut may detect the enlarged mesenteric glands which must be carefully distinguished from hardened fæces in the bowels from the ovaries, from masses of fat, etc.

The temperature is raised in proportion to the activity of the tubercular process.

Tuberculosis of womb and ovaries.—These and their supporting membranes or ligaments are often implicated in the bowel disease giving rise to undue generative excitement. They may also become primarily infected through coition. The affected cow is usually sterile, sooner or later parting with any ovum that may have been impregnated. Later her *heats* may become more intense and last longer, and never lead to impregnation. The cow spends most of her time wandering around, bellowing for the bull, and neglects to eat or ruminate and wastes away rapidly. There is often a whitish discharge from the vulva. The temperature is elevated and general tuberculosis sets in sooner or later.

Tuberculosis of the liver spleen or pancreas.—The liver is one of the first organs to suffer in infection through the stomach and bowels, and it may be exclusively affected in calves and even in mature animals. Tuberculosis of the liver may be accompanied by impaired appetite and digestion, bloating after meals, and in exceptional cases by jaundice, but often an indefinite ill-health is all that can be detected. Pancreatic and splenic tubercle are marked by a similar obscurity of symptoms. It is usually only when the disease begins to be generalized that distinct, objective symptoms are available.

Tuberculosis of the kidneys and bladder may be attended by extra sensitiveness of the loins to pinching and by frequent passage of urine, more or less discolored by blood or mixed with purulent matter. Examination of the microscopic blood casts in the urine after having stained them may reveal bacilli.

Tuberculosis of the throat. Pharyngeal glands.—This is one of the most common types in cattle. Attention is usually first drawn by a wheezing breathing, the sound manifestly coming from the throat, and the glands around that part are felt to be enlarged, unequal on the right and left sides, or shrunken and of a gristly hardness, or softened and even fluctuating on pressure. The formations above the throat and beneath the first bone of the neck, are particularly liable to undergo this special softening. There is usually a loose gurgling cough, some difficulty in swallowing, and a slimy discharge from the mouth. Small tubercular growths may exist on the lining mucous membrane, and this sometimes extends into the air passages causing *tuberculosis of the larynx* with a persistent paroxysmal cough and a harsh altered voice.

Tuberculosis of the udder.—A portion of a single quarter is usually first affected, causing a circumscribed swelling, harder than the rest of the gland, but not hot nor painful, and this gradually extends to the whole udder. With this extension the gland becomes harder, and the milk lessened, more watery and clotted, and the lymphatic glands in front of the udder and behind are enlarged, and hardened. The gradual advance of the disease serves to disarm the milker of any suspicion and the milk is commonly utilized until its watery or grumous appearance draws special attention to the gland. The case may be tested by inoculating with the milk, or less satisfactorily by a microscopic search for the bacillus, or the tuberculin test may be applied.

Tuberculosis of the lymphatic glands.—In cattle the lymphatic glands are often found to be tuberculous to the exclusion of internal organs, and as this form of the disease tends to become chronic it is likely to be overlooked for a length of time. Wherever a group of these glands exists, there may be tuberculosis. In addition to those already cited may be here named:

a. *The submaxillary glands* situated on the inner side of the lower jaw at the point where the pulse is felt. These which are almost imperceptible in their natural condition, may swell up to any size, soften, burst, and discharge a cheesy matter. They are most liable to be confounded with actinomysosis of the same region but do not show the almost microscopic hard yellow clusters of the actinomyces. They yield in place the specific bacillus.

b. *The glands at the root of the ear.*—These swell in front or behind the ear, soften and like the submaxillary glands they may or may not burst and discharge.

c. *Glands inside the chest, mediastinal, bronchial, etc.*—The mediastinal and bronchial glands lying between the lungs in the centre of the chest are often affected independently of the lungs, and give no easily available symptom. A persistent nervous cough and some unthriftiness, though on good, liberal rations, may arouse suspicion, but cannot lead to diagnosis. If the *glands on the walls of the gullet* (*œsophagean*) are implicated the vagus nerve and stomach may be involved and digestion, rumination, and the eructation of gas may be interfered with so that chronic bloating may be added to the suggestive, though by no means diagnostic, symptoms. Equally obscure are the indications of disease of the *glands beneath the back bone and those above the breast bone.* Of the more superficial glands of the trunk the following are the most easily examined:

d. Glands in front of the shoulder blade.—This group is in front of the middle of the shoulder blade, and may easily be siezed in the hands in thin cattle. If enlarged unequally on the two sides, or if very hard and nodular though small, suspicion may well attach to them. It is only on rare occasions that they burst and discharge.

e. Glands above the stifle.—These placed on the side of the flank in front of the stifle can also be grasped and examined. Indeed, in certain animals, notably in the Channel Island breeds, they can be seen by the eye. Swelling, inequality, hardness, nodularity are the usual suspicious features. Often smaller pea-like or hazel-nut-like masses are found scattered over the lateral walls of the belly from the last rib to the hip bones, and even in the interval between the two last ribs.

f. External inquinal glands.—In the male the glands on the sides of the scrotum, and in the female those on the sides of the udder may be felt to be enlarged when affected with tuberculosis.

g. The posterior cervical glands situated in the lower end of the furrow that lodges the jugular vein, may be similarly implicated and recognized.

The deeper seated groups of lymphatic glands, need not be individually referred to, for though subject to tuberculosis they rarely show as external swellings. Tubercles, however, may appear in any part of the skin. I have found a caseated mass like a hickory nut on the point of the shoulder, and fibrous warty-like growths on the skin, and open unhealthy sores with hard fibrous surroundings may be fibroid tubercle.

It must be borne in mind that the lymphatic glands are liable to become congested and inflamed from other sources of irritation in themselves and in their vicinity so that the mere fact of disease of these glands is no sufficient evidence of tuberculosis. It is however ground for grave suspicion, and further exculpatory evidence is demanded.

Tuberculosis of bones and joints.—This is especially seen in young growing animals, being common in calves in badly infected herds. Wm. Mueller has produced it experimentally by injecting the nutrient artery of the bone in a three month's goat. The bones most commonly attacked are those entering into the formation of the elbow and knee, the stifle and hock, and as the disease usually extends from the gristly growing substance in the bones of the joint surface, the trouble is recognized as disease of the joints. In some instances, however, the disease begins in the lining membrane (synovial) of the joints and forms fungous growths extending into the bone. In the open (cancellated) tissue on the end of the bone it is at first red and congested, later it is partly fatty, and caseated. Usually the disease becomes general, but if it remains circumscribed, it is enveloped in a layer of dense hard bone. The animal is very lame, perhaps even unable to rise, the joints swollen and tense, and the ends of the bones enlarged and tender. The disintregrated bone may even crumble and the sharp spiculae protrude through the skin.

Further Indications of Tuberculosis.

The above outline of symptoms seen in cattle is rendered necessary by the invariable question, "how can I recognize it?" The intelligent reader will realize from the partial sketch above, that it is no simple matter to diagnose tuberculosis. It is to be hoped that he will also have apprehended so much of the subject as will save him from being victimized, by the man who boasts loudly, but really knows little.

In the multitude of equivocal and occult cases further tests must be applied. These may be named as (1) microscopic search for the bacillus, (2) inoculation, and (3) injection of tuberculin.

Inoculation.—The first named test having been already incidentally referred to, inoculation may be noticed. This consists in the introduction into the peritoneum or other part, of a guineapig or other animal or some of the suspected product (discharge from the nose, milk, juice from an enlarged gland, etc.) General abdominal tuberculosis should be present in the guineapig in 30 days. Beside the delay, this has the draw-backs, that the guineapig may have been already infected before the inoculation, the portion of the suspected product may have been devoid of bacilli though these were abundant enough in the animal from which it was taken, or the guineapig may have become infected after the inoculation from being kept in an infected place, or from infected food, water, attendants, etc. We must first secure for the guineapig the very guarantee we are seeking for the larger animal. Is it not then better to secure this for the larger animal first and avoid all the subsequent sources of fallacy attendant on an inoculation experiment?

The tuberculin test gives prompt results and is less open to fallacy.

Tuberculin.

Tuberculin or *Koch's lymph* consists in the concentrated, sterilized liquids in which the bacillus tuberculosis has been grown. It contains no living bacillus; all germs have been killed by heating; but it does contain the chief poisons which are produced in the tuberculous body, and which bring about all the diseased processes in such body. A possible exception may be made of any such poisons as are destroyed by heat if any such there be, in tuberculous products. It must be distinctly understood that in every contagious disease there is, 1st, the germ which grows and multiplies in the susceptible animal system, but is not, in itself and by its mere presence, necessarily injurious, and, 2d, the products of the life of that germ which may or may not be poisonous. The many germs, which continually enter the animal body, have products that are not appreciably poisonous and therefore produce no disease, whereas the few that do manufacture poisonous products cause our different contagious diseases. We find a counterpart in the yeast germ which in itself is virtually harmless to man, whilst the alcohol, which it manufactures from sugar under certain conditions, is a poison more or less hurtful according to the susceptibility of the person taking it.

Tuberculin consists of chemical poisons which the bacillus secretes or manufactures, and on which the force and all the manifestations of tubercle in the tissues are chargeable. Having no living germ it cannot increase its own substance, nor can it cause tuberculosis in a healthy system as it is soon thrown out of the body through the kidneys and other channels and its power for evil is at an end, yet none the less is it the immediate agent through which all the destructive work of tuberculosis is carried on. Where the bacillus tuberculosis lives and multiplies in the animal body these chemical poisons are being constantly formed, and thus its pernicious action is continuous, not only in the seat of the tubercle but through the whole system.

Tuberculin as a Test.

The tuberculin test is based on the fact shown by Koch that it increases the activity of the disease process in tubercle, and affects the whole animal body producing a reaction or rise of temperature in a marked degree. On the ordinary tubercle as seen on the surface, the frequent use of tuberculin produced a more active process of cell growth leading to degeneration and death, so that there was a more speedy transition from the red congested nodule, through the grayish degeneration into the dead cheesy mass, cut off from all blood circulation. If this dead mass were sloughed off leaving sound tissues to heal, that particular tubercle might be cured. But deeper tubercles usually exist and these are similarly stimulated and their degeneration hastened by the tuberculin; it is impossible for them to be cast off; the increasing masses of bacilli, which have been produced under the rapid growth, are shut up in the solid tissues around to furnish new seed for a fresh extension of the disease. As such deep seated tubercles usually do exist with superficial ones, they render tuberculin almost useless as a curative agent, since to eradicate the disease the deep caseated tubercles must be afterward removed by surgical means, a resort which might have been had at the beginning and without the use of tuberculin.

But this action which renders tuberculin so objectionable as a curative agent makes it of the highest value as a test of tuberculosis in animals. The minute dose which has no effect on a healthy cow, horse or pig, when employed on the slightly tuberculous one produces an acceleration of the disease process and in eight to fifteen hours a material rise of temperature. This has been now employed on thousands of cows and those who have used it most, value it the most highly, whereas many who at first reported reactions in non-tuberculous animals are now acknowledging with Nocard that the fault has been mainly their own, for small tubercles were present but were overlooked through their failure to examine the bones and other organs.

The explanation of the reaction under tuberculin may be very simply stated. The dose is made so small that it will not affect a healthy cow under ordinary conditions. In the slightly diseased cow the system contains a certain amount of tuberculin produced by the bacillus in the tubercles, but to this the system has become accustomed and it causes no very appreciable fever. But when in addition to this we introduce into the body of this cow the small amount of tuberculin, used for the test, the increased dose acts on tubercle and nervous centres alike and a fever is produced. So evenly balanced has been the tolerance acquired, and the amount of poison tolerated with impunity, that four drops of tuberculin will as a rule produce this elevation of temperature in the moderately tuberculous cow.

Objection to Tuberculin as a Test.—1st. The temperature sometimes rises in a non-tuberculous cow after the use of the tuberculin.

This is true. So does the temperature sometimes rise in a non-tuberculous cow when no tuberculin has been employed. Every animal is liable to suffer from inflammation and fever, and if such inflammation and fever set in after the use of the tuberculin test they are liable to be charged to it as their cause. This is a valid argument against the reckless popular use of the tuberculin, but surely not against its use in skilled hands. The person who uses the tuberculin on cattle must be a trained veterinarian, acquainted with the different diseases of cattle and on his guard against confounding any one of these with the temporary fever caused by tuberculin in the consumptive. If it is claimed that every rise of the body temperature after the use of tuberculin must necessarily demonstrate the existence of tuberculosis, then truly tuberculin will be discredited. But if it is held rather that a rise of temperature after tuberculin, in a cow that furnishes to the most careful and skillful comparative pathologist no evidence of other disease, implies the existence of tuberculosis, the claim is substantially correct. To secure the valuable testimony of tuberculin, the practitioner must be highly skilled in the diseases of the animal operated on. If he is not he will be occasionally misled.

Again *heat* or *bulling* may come upon a cow after the use of the tuberculin and the temperature will rise two or three degrees. To call such a cow tuberculous would be inexcusable carelessness. Yet the condition demanded, the rise of temperature after the use of tuberculin, is present.

Again a cow that is closely approaching calving has the temperature raised. If tuberculin has been used it is often raised higher than it would be otherwise. It is therefore improper to use this agent on a cow at this period.

Active exertion, exposure in the hot sun, confinment in a close building, the privation of water at the customary time and other conditions will cause rise of temperature. But such a rise would not imply tuberculosis, even after tuberculin.

Apart from these and other such causes of error in unskilled hands, the rise of temperature under this test should be taken not as a condemnation of tuberculin, but as a stimulus to search for small occult tubercles. A thorough search will rarely prove fruitless.

2nd. The temperature sometimes fails to rise under the tuberculin test, though the animals be in the last stages of tuberculosis.

This also is true. Here the body seems to be already so saturated with tuberculin, that the small addition made in the test makes no impression, and if we trusted to the reaction alone, we would pronounce the cow free from the disease. But such cases are easily diagnosed without tuberculin. Even the unskilled more than suspect them, and a physical examination by the skilled practitioner leaves him in no doubt as to their condition. To use tuberculin on such cows is to waste an expensive agent and to run the risk of being misled. Objection based on blunders of this kind is valid enough as an argument against the use of tuberculin by the ignorant and thoughtless, but not against its use by an able practitioner.

3d. Tuberculin causes reaction in even the slightest cases of tuberculosis, in which the victims would survive for years and might recover.

This charge is also true, and it is because of its truth that tuberculin is invaluable and indispensible as a diagnostic agent, in all attempts to put an end to the disease. An eminent German professor (Eggeling) in objecting to the use of tuberculin as a general test records the following experience. In a herd of 37 reaction after tuberculin occurred in 31, while 6 gave no reaction. When killed the 6 proved sound and the 31 without exception tuberculous. But of the 31 only 1 had general tuberculosis and was condemned as unfit for food, and 1 was sold as second-class meat. The 29 brought first-class prices as meat, and having been only slightly affected would probably have lived for years without infecting others. Now it is submitted that the German standard as thus given is not radical enough to secure safety for man or beast, nor to give hope of an early extinction of tuberculosis. The meat of the animal with two or three tubercles in one organ is generally, but by no means always, free from the germ. When the disease does extend from such isolated tubercles, as often happens, the germ is carried not only in the lymph, but in the blood, and with tubercle in the body no one can tell when the bacillus has passed into the circulation and reached the different organs. Tubercles usually form slowly and the bacilli must have been in the blood for some time before they show as fresh tubercles in tissues and organs distant from the old ones. The meat of a tuberculous animal can never therefore be fully guaranteed as safe to eat. But again, while a cow with one or two tubercles only in lymphatic glands, may not be liable to transmit the disease to others, yet whenever an extension takes place, the germs being carried by the blood and therefore throughout the whole system, there must always be danger of their escape from the natural surfaces (lungs, udder, liver, bowels, etc.) to infect other animals. And let it be borne in mind, this diffusion through the blood takes place before its occurrence is revealed by the formation of tubercles in new situations. So long, therefore, as a single victim of even slight tuberculosis is left in a herd it can only be looked upon as an invitation to a renewed extension of the disease. It also may become at any moment a source of infection for man through the use of the meat or milk. It is only in degree that the contagion of tuberculosis differs, as to its sanitary aspect, from that of any one of the more contagious diseases, and in all alike so soon as we attach more importance to the preservation of an infected animal that will probably recover, than we do to the radical extinction of the disease, we undermine and destroy the effectiveness of our sanitary work. Practically all cases of foot and mouth disease recover; yet the frequently recurring epizootics of this disease each cost from $5 to $10 per head over the entire bovine population. Of the victims of Rinderpest and Lung Plague that do not speedily die practically all recover. Are the slighter cases therefore to be kept alive to perpetuate indefinitely those disastrous visitations that sweep away values of hundreds of millions? Is the remorseless scourge of tuberculosis to be perpetuated, not only in herds, but in our homes as well, to save for a few months or years some tuberculous cows? No country has ever dealt successfully with any of these animal plagues on the basis of preserving the mild cases for recovery. Always and everywhere it has been by the radical and thorough extinction of the disease germ wherever found, that success has been achieved. While this cannot be done for man, it must be done for our flocks and herds if we would ever cut off this prolific animal source of tuberculosis from the human race. Even as regards the herds themselves the stockowner who would consult his own future interests, would at any cost exclude from his barns and fields every possible source of future tuberculosis.

As will be shown below the meat and milk of tuberculous animals contain tuberculin (even when they do not contain the bacilli), and serve to aggravate any existing or latent tuberculosis in man.

4th. A fourth objection to the tuberculin test is its alleged liability to produce tuberculosis in healthy animals, or to aggravate it in the tuberculous ones.

Now tuberculin, properly prepared is absolutely sterilized, so that it can plant no living germ nor start the growth of any tubercle in a healthy animal. The further claim that it aggravates tuberculosis which is already in existence, is too true, and is the sound basis of its value as a test. As a means of testing the existence of tuberculosis in man it cannot be too strongly condemned, since no man has a right to seal the fate of his fellow for the sake of finding out if he has tuberculosis. The same condemnation must be passed on the use of tuberculin as an alleged curative agent, except in those few cases in which the tubercle is confined altogether to the surface of the body, whence it can easily be sloughed off. The existence or possible existence of an internal or deep-seated tubercle in man should forbid the use of tuberculin for diagnosis or for curative purposes.

The same remark would apply to animals if we adopt the German view that it is impolitic to destroy those that are only slightly affected. If tubercle exists, to however limited an extent, tuberculin tends to aggravate it, and the owner who wishes to preserve his mild cases cannot desire to have them made worse, which means to have the disease extended and possibly generalized.

So in government sanitary work. Unless the government is prepared to slaughter and pay for every animal affected with tuberculosis in however slight a degree, it has no right to use a tuberculin test. It is only when the State means to make thorough work in eradicating tuberculosis from the herds that the tuberculin test is at all admissible. But when the State aims at the thorough extinction of the disease in our herds this test cannot be omitted, as it is absolutely essential to success. The temporary aggravation of the disease is no possible harm, when the animal is to be promptly killed and paid for.

To sum up: The tuberculin test aggravates existing tuberculosis and is, therefore, unwarrantable for use on man or on cattle that are to be kept alive; it is, however, the only known means of detecting many occult cases of tuberculosis and is, therefore, indispensible in any systematic effort to *stamp out* the disease by the purchase and slaughter of every tuberculous animal.

MEAT AND MILK OF TUBERCULOUS ANIMALS UNFIT FOR FOOD.

In this connection we must consider two questions essentially distinct from each other and equally important in a sanitary sense. The first is the question of *infection* by the use of such food products, and has been very fully investigated by pathologists and sanitarians. The second question—is that of *poisoning* by the pernicious products of the germ and has hitherto been entirely ignored by sanitary writers and administrators. It will be convenient to consider these questions separately.

I. INFECTION BY BACILLI IN MEAT AND MILK.

First however it will be instructive to compare the geographic distribution of cattle and that of tuberculosis, not with the view of showing that most of the tuberculous infection of man comes from cattle, for it probably comes mainly from his fellowman, but to demonstrate rather that in some way the intimate relation of cattle to man is a potent agent in the extension and maintenance of consumption in the human family. To the student of this subject it is plain that where cattle are few or absent consumption is relatively less prevalent in man. In northern Norway, Sweden, Lapland and Finland where reindeer constitute the chief farm stock, about Hudson Bay and in the islands of the Pacific where no cattle exist, and in the Scottish Hebrides, Iceland and Newfoundland where cattle are few, tuberculosis is far less prevalent in man. In Algiers (a resort of consumptives) the cattle are few and live in the open air apart from the cities and tuberculosis does not increase among the natives. In Italy (another resort of consumptives) where cattle are housed, tuberculosis has become the scourge of man and beast (Perroncito). In Australia (a great resort for the English consumptive) the disease, formerly unknown, has become exceedingly prevalent, and the same is becoming true of our own Minnesota formerly so lauded as favorable to weak lungs.

In the temperate regions of Europe and the United States at least every eighth death is due to consumption. Dr. Biggs tells us that in New York City every fifth death is from tuberculosis of the lungs. He adds that in the Charity hospital of the city 30 per cent. of all deaths show old lesions of tuberculosis now become stationary. He quotes a Vienna hospital pathologist to the effect that he finds similar old stationary lesions in 85 per cent. of all post mortem examinations. This leaves but 15 per cent. who have not suffered from tuberculosis.

But our Northwest Indians furnish the most striking illustration of infection derived from cattle and fostered in man by unhygienic surroundings. Dr. Treon in the *American Practitioner* describes the poor emaciated diseased animals furnished to the tribes, how the Indians eat the liver, tallow and entrails raw and fresh, and how the carcass is dried, pounded and packed in the skins to be eaten later without cooking. The meat is eaten even though the animal may have died of disease. Dr. Holder in the *Medical Record* (August 13, 1892) gives the Indian mortality from consumption as 50 per cent. of all deaths at Green Bay, Wis., Tulalip, W. T., and Western Shoshone, Nev. He says that at Lower Brulé, Dak., scrofula is present in 60 per cent. of the Sioux under 21 years and that at Crow Creek, Dak., 50 out of a total Indian population of 1,200 die yearly of consumption and scrofula. Taken along with half as many deaths from other causes this would kill the whole 1,200 in 16 years.

These are extreme examples it is true, in which the transmission and fostering of the disease by cattle, is extended and aggravated by overcrowding and every imaginable unhygienic condition, among the human consumers.

Experimental Tuberculosis by Feeding.

The experimental transmission of tuberculosis by feeding tuburculous products was demonstrated by Villemin, Günther and Harms, Zurn, Gerlach, Johne, Kolb, Toussaint, Chauvean, Peuch, Leisering, Bollinger and a host of others, the animals infected in this way including Guinea pigs, rabbits, fowls, swine, sheep, goats, dogs, cats and birds. Infection was by no means so constant as when inoculation was performed, yet in 322 experiments recorded by Johne 13 per cent. became tuberculous. The varying results depend on a variety of causes, among which may be named :—

1st. The relative susceptibility of the various animals experimented on. As we know this varies greatly with the genus, species, family and even the individual.

2d. The condition of the digestive organs at the time of feeding. The bacillus tuberculosis lives in an alkaline or neutral medium and suffers weaking or even death in an acid liquid like the contents of the stomach during active digestion. If therefore the subject of experiment has a strong digestion, and if infecting matter is taken only during active digestion, infection is usually promoted. If on the other hand the infecting material passes through the stomach in water or otherwise in the intervals between digestion when the stomach is neutral, if there is indigestion so that the contents are only mildly acid, and infecting morsels pass into the bowel without having been digested or thoroughly impregnated with acid, or if the stomach is overloaded so that part of its food passes on undigested, then manifestly infection is possible or probable. Again if there are raw sores on the mouth, throat or gullet or if the germ happens to lodge in the recesses of the bowels or pass down into the lungs infection may start from any such point as a center.

3d. The germ is more or less virulent according to the animal from which it is derived. Thus the virus from the ox which proves certainly fatal to the guineapig on inoculation, cannot be successfully inoculated under the skin of the guineapig after it has passed through several generations in as many birds, but if inoculated from the bird in the abdomen of the guineapig and continued for several generations in this rodent it reacquires all its former potency (Nocard, etc.). So to a less extent with cattle; from one cow the inoculation invariably produces the disease; from another only occasionally. The same must hold in feeding.

4th. The degree of infection of the material fed has much influence. Tuberculous glands, and tubercles whether recent or caseated are of course the most certainly infecting. The blood and red flesh (in the ox) may be said to be the least frequently infecting, while the infecting power of milk will vary according as the udder is or is not the seat of tubercle. Toussaint who seems to have met with especially virulent cases inoculated successfully with the blood, nasal discharge, bile, urine, tears, flesh juice, dung, etc., of a tuberculous cow. Others like Nocard and McFadyean have failed with blood and flesh juice. The danger may be estimated by taking a middle position. It may be well to consider the blood, flesh and milk separately.

Dangers from Blood.

It cannot be denied that blood is inimical to this bacillus as to most other microbes. Even if the virus is injected into the veins in such quantity as to produce general tuberculosis, the germs become largely arrested in different organs or robbed of their virulence so that in a few days the blood is comparatively little infecting. This does not, however, do away with the fact that the injected bacilli live long enough in the blood to produce tubercles in many different organs, and the same is true when the disease extends from single primary tubercles, to a general tuberculosis; in most cases the bacilli can only have travelled through the blood. Bang found that of 20 cows in advanced tuberculosis, the blood of only two (or 10 per cent.) proved infecting when inoculated. Nocard has never succeeded in producing the disease by injecting the blood of a tuberculous ox into the abdominal cavity, yet he recognizes that as the disease extends by means of bacilli conveyed by the blood, this liquid must be infecting wherever these bacilli are contained in it. As the migrating bacilli must be present in the blood before these secondary tubercles can be formed by them in organs distant from the tubercles that gave them birth, it follows that this infecting condition of the blood must precede the formation of the secondary tubercle, or general tuberculosis. While therefore it is quite true that the probabilities of infecting blood are greatly increased when the tubercles are numerous and generally diffused, it is an error to assume that the restriction of the tubercles to one organ is a guarantee that the blood is non-infecting. And when we cannot give a guarantee for the blood we can give none for any part or organ in which blood circulates.

Danger from Flesh.

It would seem as if the muscle or red flesh in cattle were antagonistic to the bacillus tuberculosis. Certain it is that tubercles are rare in the substance of the muscle. They are, however, very common in the lymphatic glands lying between the muscles, and in swine they are common in the substance even of the red flesh. The flesh of tuberculous pigs is therefore far more dangerous than is that of consumptive cattle. Even in tuberculous cattle, however, the beef is not always free from bacilli as shown especially by the crucial test of inoculating its juice. Arloing tested 10 tuberculous cattle in this way by inoculating guinea-pigs and found that the muscle from two of the cows only (20 per cent.) proved infecting, and that only 3 of the 10 guineapigs inoculated by the muscle juice of these two cows became tuberculous. Galtier fed two calves and two young pigs with the raw flesh of a tuberculous cow, but failed to infect them. This failure was, however, not necessarily due to the absence of bacilli, since two rabbits inoculated with juice from the same flesh contracted tuberculosis. Nocard fed several litters of young kittens on the flesh of cattle condemned as tuberculous, at the abattoirs of La Vilette and Grenelle, but none of them contracted tuberculosis.* Perroncito fed 18 young pigs from three to five months on the flesh of cattle condemned as tuberculous in the Naples abattoirs, yet none became tuberculous.

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*By inoculation with the muscle juice of tuberculous cattle Nocard infected 5 per cent. of the subjects of experiment.

Two things are shown by the above: (a) that the red muscle is less frequently infecting than other parts, yet unquestionably so in some cases; and (b) that the acid stomach juices during vigorous digestion are in some measure protective. It is equally plain that no sufficient guarantee can be given as to the safety of the raw flesh in any particular case. Then, again, the intermuscular lymphatic glands, which are favorite seats of infection, were carefully avoided in the above experiments with flesh juice, yet they always go with the dressed carcass and are eaten with its steaks and roasts. In pigs, as already noted, the muscle itself is often tuberculous.

Danger from Milk.

Milk is more to be dreaded than meat because the udder is often the seat of tuberculosis, and the milk is usually taken uncooked. The danger is enhanced by the fact that this is often the necessary and only food of the infant and invalid, in which the germ is especially liable, through weak and imperfect digestion, to escape into the susceptible bowel.

In milk, as in the case of meat, a strong, vigorous digestion does, in some measure, protect the consumer. Peuch fed a two months' pig in five days 4½ quarts of milk drawn from a tuberculous udder, and killed in 56 days it proved quite sound. He inoculated four rabbits with the milk and all four became tuberculous. Again, in the absence of tuberculosis in the udder the milk may be little, if at all, infecting. Gerlach, who produced tuberculosis in calves, pigs and rabbits by feeding the milk, found no result from certain tuberculous cows, while others infected a large proportion. Nocard and McFadyean have been unable to infect rabbits, etc., with milk from an apparently sound udder of a tuberculous cow. The same has been my experience with milk from one cow in the last stages of chronic tuberculosis, and another having acute tuberculosis. Bollinger, Nocard and McFadyean claim that in the absence of tubercle in the udder the milk is not infecting. Whether true or not as an ultimate fact this cannot be made a rule of action, as the following will show:

Hirschberger inoculated rabbits in the abdominal cavity, with the milk of 29 tuberculous cows of which the udders were or appeared sound, and produced tuberculosis 14 times.

Bang inoculated from 63 tuberculous cows selected for their sound udders, and found the milk of 9 of them infecting. A careful microscopic examination revealed tuberculosis in the udders of three of the cows, leaving six giving infecting milk in which even after death, and with all scientific appliances no tubercle could be found in the udder. This is 9.5 per cent. as tested by the microscope after death; it was 14.28 per cent. as tested by the able veterinary professor during the life of the cows.

Ernst found 10 cows in 35 with infecting milk though the udders were sound. In 103 animals inoculated 17 contracted tuberculosis, and of 12 calves sucking the cows 5 became tuberculous.

Drs. Smith and Kilborne (Bureau of Animal Industry, Bulletin No. 3.) found the milk infecting in three cows out of six with apparently sound udders. One infecting cow, and one non-infecting one had each tubercle in the lymphatic gland behind the udder. Forty-four per cent. of the inoculated Guinea-pigs contracted tuberculosis: 1 in 5 from one cow, 8 in 10 from another and 6 in 6 from the third

In my own experience three calves, from healthy parents, sucking the apparently sound udders of three cows with general tuberculosis all contracted the disease.

It must be allowed that calves sucking the cows run extra risk of infection through their nurses licking them and through feeding from a common trough, but there is the same danger for the ordinary milk consumer, since the cow in licking her udder is liable to leave bacilli to fall into the pail at the next milking..

Again the concentration of the bacillus in the indiluted milk of an infecting cow, renders this much more dangerous than the milk of the same cow diluted,· with that of 20, 50 or 100 others. Bollinger and Gebhardt found that milk which infected all animals that took it pure, was apparently harmless when diluted with 50 or 100 times its volume of the milk of sound cows. As the bacillus can live in milk this apparent loss of virulence must be largely due to the reduction of the number of bacilli in a given measure of milk, and to their tendency to removal by adhering to the sides of the vessel during the mixing.

Tuberculous expectoration which is incomparably richer in bacilli may be diluted in 100,000 times its volume of water and yet remain infecting. But again the glutinous saliva forms a protecting coating which strongly resists dilution.

Infection of Man Through the Milk.—Instances of accidental tuberculosis of the human being through drinking the unsterilized milk are no longer wanting.

In the practice of Dr. Stang of Amorback, a well developed five year old boy, from sound parents, whose ancestors on both male and female sides were free from hereditary taint, succumbed, after a few week's illness with acute milliary tuberculosis of the lungs and enormously enlarged mesentric glands. A short time before the parents had their family cow killed and found her the victim of advanced pulmonary tuberculosis. (Lydtin).

Dr. Demme records the cases of four infants in the Child's Hospital at Berne, the issue of sound parents, without any tuberculosis ancestry, that died of intestinal and mesenteric tuberculosis, as the result of feeding on the unsterilized milk of tuberculous cows. These were the only cases in which he was able to exclude the possibility of other causes for the disease, but in these he was satisfied that the milk was alone to blame.

After a lecture of the author's at Providence, R. I., a gentleman of North Hadley, Mass., a graduate of the Massachusetts Agricultural College, publicly stated that his only child, a strong, vigorous boy of one and one-half years, went to an uncle's for one week and drank the milk of a cow which was shortly after condemned and killed in a state of generalized tuberculosis. In six weeks the child was noticeably falling off and in three months he died, a mere skeleton, with tuberculosis of the abdomen. The father could trace no tuberculosis among his near ancestors, but the mother's father and uncle had both died of it. She remains in excellent health.

Dr. E. O. Shakespeare (*Med. News*, March 26th, 1892) attributes one-fifth of all deaths in infants and young children, feeding on milk, to tuberculosis usually commencing in some part of the digestive organs.

Identity of tuberculosis in cattle and man.—This is abundantly proved in the above instances of the infection of man through the milk and in the hundreds of cases in which the tubercle of man has been successfully inoculated on the lower animals. As evidence of direct transference of the disease from cattle to man by inoculation the following two cases are quoted :

Tscherming, of Copenhagen, attended a veterinarian who had cut his finger in making a post mortem examination on a tuberculosis cow ; the wound healed, but there remained a swelling which soon ulcerated and refused to heal, so that the whole tumerfied mass had to be cut out. The microscope revealed the distinct tubercular process and the presence of the characteristically staining bacilli.

Pfeiffer attended a Weimar, veterinarian of the name of Moses, 34 years old, of a good constitution, and without hereditary predisposition, who, in 1885, cut his right thumb deeply in making a post mortem examination of a tuberculous cow. The wound healed but six months later the cicatrix still remained swollen, and in the autumn of 1886 the man had pulmonary tuberculosis with bacilli in his sputa and death occurred in two and a half years after the wound. Post mortem examination revealed tuberculosis of the joint of the wounded thumb, and in the lungs extensive tubercles and vomicæ.

To Tscherming's may be added the case of a young veterinary friend of the writer, who was inoculated in the hand in opening a tuberculous cow, and suffered from a tumefaction of the resulting cicatrix, with distinct tubercle bacilli. The surgical removal of the tumefaction manifestly saved the subject from a generalized tuberculosis.

II. POISONING BY PTOMAINES AND TOXINS, IN MEAT AND MILK OF TUBERCULOUS ANIMALS.

By an unaccountable oversight medical and veterinary Sanitarians alike have never, up to the present hour, looked beyond infection by the tubercle bacillus in estimating the dangers to man of tuberculosis in our flocks and herds. We find accordingly that the question kept continually before the public is that of the presence or absence of the tubercle bacillus in any food product,—meat, milk, butter or cheese—furnished by the diseased or suspected animal. The question of the presence or absence of ptomaines or other toxic elements which are calculated to prove hurtful or even fatal to certain members of the human race is not for a moment considered.

Hence we are met by the most elaborate arguments that tubercle is rare in the muscular system of cattle, and that muscle juice is inimical to the bacillus and that therefore the muscular tissue which forms the great mass of the dressed carcass may, as a rule, be safely eaten even though the internal organs may have been affected by tubercle. In Germany and other European countries the flesh of animals in which the tubercles are found in only one organ or in two related ones, is passed as wholesome. It is only when the tubercles are found in the bones, or muscles, or in the lymphatic glands among these, or finally when the tubercles are so generally distributed in different parts of the body that it is evident that the bacilli must have been carried by the blood, that the meat is rejected as unfit for human food. So with milk and other dairy products; many claim with Nocard and Mc Fadyean that the milk is harmless so long as the udder is quite free from tubercle, and that it is only when tubercle is unmistakably present in that gland that this secretion is to be feared. Apart altogether from these discussions as to the wholesomeness of uncooked flesh and milk it is safe to say that up to the present, every writer on the subject holds that even the infecting tuberculous meat and milk is rendered absolutely harmless by cooking. The consensus of professional opinion on this subject is tersely given by Salmon and Smith in their article on tuberculosis in the work on the "Diseases of Cattle" published by the Bureau of Animal Industry—"Fortunately tubercle bacilli are readily destroyed by the temperature of boiling water, and hence both meat and milk are made entirely safe, the former by the various processes of cooking; the latter by boiling for a few minutes."

But this is altogether too narrow a view to take of the subject, and it is liable to lead to most serious and fatal results if put into every-day practice. The professional mind, in concentrating its attention on *tubercular infection*, has practically entirely overlooked the no less real and, in many cases, no less dangerous fact of *tubercular poisoning*. To elucidate this matter let us consider that much of the poisonous matter produced by the growth of the tubercle bacillus is retained in Koch's "tuberculin," which has been absolutely sterilized. What, then, is the action of "tuberculin" on the animal system? It produces a constitutional disorder with elevation of the body temperature, commonly known as fever, and an impairment of most of the bodily functions, notably those of assimilation and secretion. This is abundantly manifest in the wasting and fever of the victim of acute tuberculosis in which these poisonous principles are being constantly produced in large quantities. As the dose is reduced, a point is finally reached at which no fever nor appreciable systematic derangement is produced, and thus in many slight and indolent cases of tuberculosis the animal appears well, and thus, also, the usual test dose of tuberculin has no recognizable disturbing effect on the healthy animal system. With a dose less than this it may even be questioned whether it may not be actually beneficial in conferring on the healthy system a small measure of tolerance and power of resistance to the bacillus and its poisons. This, however, is of little account, seeing that no real immunity from tuberculosis is ever acquired. In many systems, both human and brute, the disease continues its slow progress for many years, and the slight tolerance that results, while it may suppress the disease so that it assumes an indolent and chronic form, does not fully arrest it.

Very different is the effect of even a minimum dose of tuberculin on a subject which is already attacked with tuberculosis. In such a case the products of the existing tubercle, circulating in the blood and tissues, are often so small in amount and the system has acquired such a tolerance of them that there is no manifest disturbance of health and the animal may even be in excellent condition. But add to this minimum amount of poison already in the system a small quantity of tuberculin and in ten or fifteen hours the temperature of the patient's body will rise two or more degrees above the normal, and the destructive process going on in the seats of the tubercles will be accelerated. In cattle this is now used as a most valuable test of the presence or absence of occult tubercle. In horses and other animals, the subjects of of tuberculosis, "tuberculin" causes the same rise of temperature, and this rise may be accepted as a rule applicable to all classes of animals. In the tuberculous man this action of "tuberculin" is a well established fact, and was made the basis of Koch's employment of this material as a curative agent. The daily use of tuberculin in cases of lupus or other superficial forms of tuberculosis led to a more active congestion and an earlier molecular death of the tissues of the local tubercle, until these were separated from the living, healthy parts and the progress of tuberculosis in that part was arrested. If there were then no deeper unseen tubercles left in the system, a real cure might be effected in this way. But the cure in such a case was only secured by a temporary aggravation of the disease in its primary focus. If other tubercles existed in internal organs they, too, had the morbid process aggravated and extended and the death of tissue increased by the fresh introduction of tuberculin from without. In such a case the increased mass of tubercle—dead and living—remained confined in the midst of the surrounding tissues, and as the infecting materials could not be cast off and separated from the body, they continued their ravages with an increasing force in proportion to their recent artificial extension.

It is this extension of the tuberculosis under the influence of the toxic products of the bacillus which raises the most important question in connection with the consumption by man of the flesh and dairy products of tuberculous animals and yet this question has been overlooked by sanitarians in the most unaccountable way. It has seemed enough for them that the living tubercle bacillus did not exist in the juices of the muscles nor in the milk. It seems never to have occurred to them that all the soluble poisonous products of this bacillus were constantly circulating in the blood which passes through the muscles, and that they equally traversed the blood vessels of the mammary glands and escaped into the milk. No pathologist can for a moment doubt this general diffusion of these products in the tuberculous subject.

Accepting then as undeniable the presence of the soluble chemical poisons in blood, flesh and milk, it follows that those who eat this flesh or milk are continually taking in small doses of tuberculin, and that in case they are already the victims of tuberculosis in however slight or indolent a form, this continuous accession of the poison will rouse the morbid process into greater activity and secure a dangerous extension.

If we now consider the frightful prevalence of tuberculosis in the human race, that here in New York every eighth person dies of tuberculosis, that in cities like Vienna 85 per cent. of the people suffer from it, and that in our own cities 30 to 50 per cent. contract it at some period of life, we see what a fearful risk is being run by the utilization of the meat and milk of animals so affected, even if it could be shown that such meat and milk were in themselves free from the living bacillus. Such reckless consumption of the products of tuberculous animals can only be looked on as a direct means of sealing the fate of that large proportion of the community which are already slightly affected with tuberculosis.

The claim that the canning of tuberculous carcasses and the boiling or Pasteurizing of milk does away with every element of danger can no longer be entertained. Sterilization is not a restoration to a non-poisonous condition ; it does away with the possibility of infection, it is true, but it does not render the product innocuous.

As a matter of fact Koch's tuberculin has been sterilized by heat, but this has not by any means rendered it safe and harmless. On the contrary it invariably intensifies any existing tuberculous process and develops fever and general constitutional disorder. When tuberculin, therefore, is present in meat and milk it can only cause these to operate in the same way on subjects that have been already infected. In my experience with tuberculous cows, cases have come to my knowledge in which invalids drinking the milk of such animals have suffered very obviously and have improved after such milk was withheld. So too in the case of calves sucking phthisical cows ; they have done badly and proved unthrifty though they took the whole of the milk furnished by their respective nurses, and they have thriven better when weaned and put upon solid food alone. I have followed some such calves until they grew up and were slaughtered, and have made postmortem examinations and found them bearing old calcified tubercles pointing back to the time when they sucked the infected and poisonous milk.

It is idle to say that such milk was merely lacking in nutritive principles :—the calves in question had access to other food, while following their nurses, and would not have been harmed by taking the same amount of pure water as they took of milk. Apart from the bacilli, which operated slowly, and which allowed these animals to live for years and even thrive after they had ceased taking the milk, there was unquestionably in this secretion a definite poison which undermined the health and stimulated the progress of the tuberculous process. Accessions of bacilli are not denied, but at the worst these acted tardily, and apart from the soluble poisons their action must have been cumulative up to the cessation of the milk feeding, so that immediately after the withdrawal of the milk the morbid action should have been greater than at any time before this, whereas in the cases in question improvement dated from the change to dry coarse food.

K. Yamagiva in his experiments on guineapigs obtained corresponding results. After inoculation with tubercle, the administration of tuberculin greatly hastened the onset of general tuberculosis so that after a week tuberculous centres were found in lymphatic glands, spleen, liver and lungs.

If this is the result in guineapigs which though very subject to tuberculosis are not easily poisoned by tuberculin, how much more so in man who is many thousand times more susceptible to tuberculin? The healthy guineapig is almost unaffected by 2 grammes of tuberculin, while man weighing eighty times as much is seriously affected by $\frac{1}{20}$ gramme. In the tuberculous condition the guineapig reacts violently under ¼ gramme, while man is seriously affected by $\frac{1}{1000}$ gramme. Weight for weight being considered it follows that the consumptive man is 20,000 times more susceptible to the tuberculin poisons than is the guineapig. From this may be inferred the danger to the tuberculous man, of meat or milk containing the poisons of tuberculin.

It may be safely held as proved, by analogy, observation and experiment that the soluble poisons of tuberculosis invariably operate by exaggerating any existing tuberculous process, and that blood and all animal fluids becoming charged with such poisons uniformly tend to further endanger the health or even the life of any person who may consume them while suffering from tuberculosis.

We may freely allow that the transmission of the bacillus from man to man is far more common than from beast to man. But though the implanted seed may have been in many cases derived from a fellowman, its subsequent destructive progress may be due far more to the constant accessions of the soluble poisonous products conveyed in the meat and milk of tuberculous animals. Without these constant doses of soluble poisons of tubercle, the implanted germ would in many cases have proved comparatively harmless. Although it could be proved in regard to many cases that the cow had not contributed the seed of the diseases, she is left little less responsible for the destructive progress and fatal result. The germ which might have remained comparatively dormant and harmless in the absence of the poisoned meat and milk is by these stimulated to a more deadly energy.

HOW TO MEET THE DANGER.

This hitherto unchallenged factor in the progress of tuberculosis, opens up new and uncultivated fields for sanitary work. The great evil ventilated in this paper cannot be effectually met without the eradication of tubercolosis from every herd kept for the supply of food products for the public. Nothing short of this can be trusted to act satisfactorily in putting a check upon the present fearful mortality from this disease. No inspection of dressed carcasses, nor of milk, butter and cheese will furnish a guarantee. We must go to the herds and subject them animal by animal to a critical test, and only accept the products as safe when there is no longer a shadow of suspicion remaining. A professional examination of the most searching kind must be supplemented by the "tuberculin" test before a clean bill of health can be furnished. In my own experience on cattle two thirds of the cases of tuberculosis sometimes escaped under the most critical professional examination and were detected later by the "tuberculin" test. Often, when cattle were condemned by the "tuberculin" test, have the owners pronounced them the most thrifty and the least suspected in the herd, and it was only after slaughter, when the bodies were opened and the caseated tubercle exposed, that they were satisfied that no mistake had been made. Recently in a herd kept for the supply of high priced milk of guaranteed soundness, the stock having been subjected to weekly examinations by a veterinarian, the "tuberculin" test was applied and 50 per cent. of the herd demonstrated to be tuberculous. Without the "tuberculin" test there is no guarantee possible for the products of the dairy, and the sanitary officers who will affect to deal with this disease in herds without the aid of "tuberculin" are at best but pruning the tips of the branches of the evil tree. Public money ought not to be thrown away on such fruitless and ineffective work. The purification of a herd must be followed in every case by a thorough disinfection of contaminated buildings and places, and by a careful seclusion of the herd from new sources of infection. It is evident therefore that the nontuberculous herd must be secured against the addition of fresh animals from any herd that has not been similarly attested sound, and that any necessary addition from another source must be tested by "tuberculin" before it is added to the herd. Equally important is it to test all farm animals of whatever species which live on the place and cohabit with the herd, and to see to it that no human being suffering from tuberculosis is allowed to attend to the animals or to prepare their food. It is difficult to see how anything short of such a system can afford a guarantee of the absence of the soluble tubercle poisons from our milk, butter and cheese.

In the case of butcher meats a professional examination when slaughtered, covering all of the viscera as well as the carcass, will be essential, and the current doctrine of sound meat with localized tuberculosis must be abandoned. Every municipality must have its own public abattoir in which alone its meat supplies should be butchered and where every carcass should be systematically examined as it is opened. Private slaughter-houses controlled by individual owners afford endless opportunities for the evasion of sanitary statutes, and ought to be abandoned as relics of an age when modern sanitary science was unknown.

The question of dressed, canned and salted meats is one that must be carefully considered. It is quite evident that such products must come to us with a sufficient guarantee if allowed to compete with our home meats which have passed the municipal inspection. It is equally evident that no inspector paid by the packer or canner can furnish a certificate which will command public confidence. The inspector must be a government official who is entirely independent of the packers and who is in no way dependent on their good will.

Then again the existing method of furnishing government inspectors at our great packing centers only, and thus giving a monopoly to the large operators, cannot be long maintained in a country of equal rights and privileges. The most obvious cure for this evil is to make all packing establishments government institutions, where the small packer shall have equal privileges with the large, and where all carcasses shall be subjected to the same scrutiny and all shall go out with the same guarantee.

Such a proposition will doubtless be severely criticized both from the medical and economic standpoint.

On the medical side it will be argued that if the soluble poisons in the meat and milk were as injurious as represented, we would see the evil results on every side and that medical men would be universally cognisant of them. And yet do we not see clearly to-day much that was never suspected twenty, thirty or fifty years ago? How recent is the acceptance by the profession of the doctrine of contagion in tuberculosis, in tetanus, in pneumonia, in influenza, in glanders, etc. Are we to suppose that our forefathers were surrounded by fewer evidences of contagion, at a time when no precautions were taken to prevent it, than we are with all the antiseptic and antizymotic provisions of the present day? The facts of contagion were doubtless more abundant in their days than in these, but their attention had never been drawn to them. So now let the attention of physicians and sanitarians be given to the morbid action of soluble poisons of tubercle and evidences of their evil results will accumulate on all sides. It is the scrutiny and not the facts that are wanting.

The economist will object to drastic measures for the suppression of tuberculosis on the ground of expense. Who is to pay for the municipal abattoirs, the inspectorships, the disinfections, and the indemnities for slaughtered animals? In return let me ask, who now pays for the constant losses of live stock which the proposed system would put a stop to; for the frequent infection of sound herds by unfortunate purchases of animals that prove to be tuberculous; for the losses to the nation, to the community and family of the tuberculous one-eighth of all deaths; for the loss of work—literary, scientific, manufacturing, commercial, domestic and manual of the great host of consumptives waiting all over the land to fill the places of this fatal eighth in coming mortality statistics; for the losses represented by the bills of the physician, nurse and druggist for these invalids; and for the losses represented by the many migrations and exiles in search of health and of the costly consumption hospitals and sanitaria? And who is to pay in the future for the needless harvest of similar fruits, which the seeds now sown through our supineness, must inevitably produce in the coming generations?

Is it not a truer economy to destroy the seed before in has germinated, or even before it has been sown, than to wait for the multitudinous evils that must attend on its growth and fructification?

PREVENTIVE MEASURES FOR ADOPTION BY THE STOCKOWNER.

If he will the stockowner can extirpate this disease from his herd and thereafter keep the herd pure from such contamination. The following are the main precautions necessary to this end:

1st. Board up the partitions of the stalls at the front so that no two cows can feed from the same manger nor lick each other.

2d. Keep each animal strictly by its own stall and manger.

3d. When any animal is suspected don't let it use a drinking trough nor bucket in common with other animals.

4th. Avoid old milch cows and unthrifty ones, or keep them secluded from the rest of the herd.

5th. The following conformation usually indicates a weakness of constitution and a susceptibility to tuberculosis: Head narrow between the horns, sunken eyes, depth of cavity (temporal) back of the eyes, thin narrow ewe neck, chest small, lacking in both breadth and depth, hollow flank and tendency to pot belly, a general lack of muscle so that the limbs seem loosely attached to the body, in breeds that show a variety of colors, animals of the lighter shades of brown and yellow. If, however, such animals are of high value for the dairy, and can be kept free from infection they need not be rejected. The finest conformations of shorthorns, Devons, Holsteins, black or red polled furnish no protection in the presence of the germ.

6th. Don't purchase from a herd in which tuberculosis has appeared or in which cattle have died or been killed within a year or two. Resort first to the tuberculin test.

7th. Don't take a cow with a husky or rattling cough, wheezing, hurried breathing, discharge from nose, fœtid breath, hard bunches under the skin, diseased udder, swollen bones or joints, unthriftiness, or a tendency to scour or bloat.

8th. Don't purchase from city, suburban nor swill stables.

9th. Don't add newly purchased cattle to your herd until you have tested them with tuberculin, especially if they have been the product of inbreeding.

10th. Don't admit strange cattle to house, field nor yard with your own; keep them apart until tested with tuberculin.

11th. In case of disease or unthriftiness in your herd put the animal apart and have it examined by a skillful veterinarian.

12th. If after this there remains any doubt as to the real nature of the disease, have the animal tested with the tuberculin, in the hands of a practitioner thoroughly acquainted with cattle and their diseases. If the result is not yet quite clear keep the animal by itself and repeat the test in four weeks.

13th. In case one animal in a herd shows tuberculosis test the whole herd with tuberculin.

14th. Test in the same manner all animals on the farm (swine, goats, sheep, horses, rabbits, cats, dogs, fowls) that cohabit with the cattle.

15th. Kill all tuberculous animals and boil, burn, dissolve in acid, or bury deeply in a place to which no animals have access.

16th. Disinfect premises thoroughly, also all products of the diseased animals and all articles used about them.

17th. Let no consumptive person attend on cattle or other live stock, nor prepare their food.

18th. Vermin (rats, mice, sparrows) in a building where tuberculous animals have been, should be exterminated.

STATE MEASURES FOR THE PREVENTION AND EXTINCTION OF TUBERCULOSIS IN FARM ANIMALS.

The best, most effective, and economical measures for the suppression of tuberculosis are those which naturally devolved on the State. It does not follow, however, that State interference will exonerate the stockowner from his personal duty in taking the precautions laid down for him above. It is the duty of the State to see that all such precautions are enforced, together with others that transcend the power of the individual stockowner, and must be undertaken by the governing power for the public good. Among these may be named the following :

1st. The providing of municipal slaughter houses in which alone farm animals designed for human food can be slaughtered.

2d. Exclusion from the home market of all dressed, salted and canned meats, that have not passed a crucial examination at the time of slaughter by an accomplished government veterinary inspector.

3d. Government stamping and labelling of all canned meats that have passed the municipal inspection and can be guaranteed as from nontubercular animals.

4th. Forbid the use for pigs, fowls or other animals of all milk furnished by tuberculous animals, and of all offal or other products of slaughter-houses until they shall have been boiled for one hour.

5th. Provide for the systematic inspection by skilled and reliable veterinary practitioners, of all dairy herds and primarily of such as furnish milk for immediate use as sweet milk.

6th. If tuberculous cattle or other animals are found in a herd, have the remainder tested with tuberculin, and have all affected cattle appraised, killed, and, without delay or further expense, paid for by the State.

7th. Appraisers may be chosen one for the State and one for the owner, or better, to secure a more even handed justice, all alike should be valued by two State appraisers chosen for their knowledge of animals and their values, and for their integrity.

8th. Indemnities should be paid without delay on presentation of the affidavits of the stockowner, the inspector and the State appraisers.

9th. The precautions prescribed for private owners under the headings 9 to 15, and 18 should be carried out under the supervision of State officers.

10th. Disinfection of all contaminated premises and objects should be done at State expense and by a special disinfecting corps under a trained, careful and thorough foreman.

11th. Attendants on cattle or other meat producing animals, who show any chronic disease of the air passages, lungs or bowels, should be examined for tuberculosis, by the municipal or town health officer, and their expectoration should be tested bacteriologically. If found to be tuberculous they must be forbidden to continue this occupation.

12th. Though herds have been tested and guaranteed sound, such guarantee must lapse as soon as new animals are introduced into them from public markets or untested herds. The guarantee may be preserved by having all such additions tested by tuberculin before they are added to the herd.

13th. In making tests with tuberculin the inspector will, as a rule, omit cases that are suffering acutely from other diseases or from advanced general tuberculosis, or that are approaching *œstrum* or parturition, such cases must be secluded and tested later when there is no such source of fallacy.

14th. All deaths in inspected and attested herds should be promptly reported to the government veterinary inspector of the district, who should make a careful post mortem examination and if he finds tuberculosis in even a latent form, the whole herd should be again tested with tuberculin.

DEFECTS OF THE EXISTING NEW YORK LAW.

New York is to be highly commended for taking an advanced position in the suppression of tuberculosis by process of law. It is to be regretted, however, that excellent intentions have been somewhat marred from a lack of acquaintance with the diseases of the lower animals, by those who have drawn and those who directed the administration of the law. It may not be altogether useless to name some of the more obvious defects in the law as hitherto in force.

A. THE PROVISION FOR TWO SEPARATE VETERINARY SANITARY BOARDS.

By existing law tuberculosis and glanders are dealt with by the State Board of Health, while all other diseases affecting the same genera of animals are placed under the supervision of the Commissioner of Agriculture. The inspector under both central authorities ought to be a veterinary comparative pathologist acquainted with the whole range of animal diseases in order to deal with one—say tuberculosis—to the exclusion of other affections, and yet when he meets with another contagious disease he is helpless to do anything in the matter, and so are his superiors; application must be made to another department, which must send its own inspectors, though an entirely capable government employe is already on the ground, and an entirely new set of machinery must be set in motion to accomplish what could have been done far more promptly, effectively and cheaply by the inspector and bureau which were already in the field. Two bureaus with their officers and records are delegated to do work which naturally belongs in one, and delay, inefficiency and unnecessary outlay can be the only results of such an extraordinary distribution of functions.

B. DELAY IN KILLING THE DISEASED.

When an animal is condemned as tuberculous, it is not in the power of the inspector to at once suppress the danger, by seeing to the destruction of the beast; he must report to his superior in Albany and recive his order before he can go a step farther. The enforced delay hinders him from attending to other cases promptly and greatly enhances the cost of the work. By employing trustworthy inspectors only, allowing them to dispose of the sick and dangerous at once, and having their reports checked by the affidavits of the owners and appraisers, the work can be rendered far more effective and economical.

C. NO PROVISION FOR APPROVED APPRAISERS.

The law says the condemned animals shall be appraised, but fails to say how, and in the past the owner of the stock had to chose his own appraisers and the claims based on such appraisements naturally came up for liquidation under a cloud of discredit as having been made by men acting in the interest of the stockowner. No wonder that in some cases the loser of a tuberculous animal found that the cost of establishing his claim amounted to more than the claim was worth. Two appraisers mutually chosen for State and stockowner, or still better, two honorable State appraisers who shall make affidavit to each estimate of value will do evener and more substantial justice to the owner of the stock, and the appraisement will come up for liquidation without the suspicion that attaches to such documents under the present system. If these are judiciously selected for skill and integrity, their awards, backed by the affidavits of the owner and inspector, will come to the disbursing officer with the best possible guarantee of their justice.

D. REFERENCE TO THE COURT OF CLAIMS.

By the present law every award for animals killed must be considered and allowed by the Court of Claims. The object is to secure justice, but it is manifest that the precaution begins too late. The Act leaves the owner to select his own appraisers, and unscrupulous persons may conspire to secure an excessive award in spite of the best efforts of the Court, who have never seen the animals valued, and can only act on the evidence furnished. The way is open therefore, for the unprincipled to prey on the State, while the man of principle correspondingly suffers. The remedy is to have appraisers, state officers and trustworthy men, in which case their decision will be at once more intelligent, fair, and equitable, than any revision that can possibly be made by a court sitting at a distance, however able and honorable its judges may be.

E. DELAY IN PAYING INDEMNITIES.

As a necessary consequence of the reference to the Court of Claims, much time is lost in preparing the case and in waiting the turn of the particular entry on the list. As a rule hearings have been had from nine to twelve months after the slaughter of the animals. This is no real advantage to the State which is saddled with the attendant Court expenses. It is often a serious matter to the stockowner, who is thus kept out of his source of livlihood, or has to borrow and pay interest on the money-value of the animals killed. Knowing the consequences of such delay, and that in addition to this they must expend considerable money in preparing and presenting their claims before the Court, and in furnishing witnesses, many prefer to make no report of the disease to the authorities but to deal with it themselves. If men of high principle they personally bear all the losses, but if not, they too often send the diseased animals to market and thus provide for the starting of new centres of infection, or they slaughter them and sell the carcasses as human food. Thus the system of indemnification, surrounded, as it is by delays and uncertainties, becomes a means of spreading instead of restricting or extirpating the affection.

With the obvious safeguards of the affidavits of worthy men acting as inspectors and appraisers, for the State, and with the endorsement of their superior officer, payments could be made promptly, and the dread of serious loss would no longer deter stockowners from coöperating heartily with the State in the purifying of their herds. Relieve the owner of the present vexations delays, of the legal and court expenses and the State will be furnished with a powerful lever for the work of suppressing the contagion.

F. NO PROVISION FOR EFFICIENT DISINFECTION.

The existing law provides no definite means for the disinfection of contaminated premises, and, therefore, this most essential duty is thrown upon the owner to accomplish at his own expense and too often in his own way. Yet the extreme measure of killing the infecting or diseased animal entails the imperative duty of thoroughly disinfecting the place where such animal has been. Without this the expropriation and killing is a comparatively futile procedure. In the hands of an inexperienced farmer the attempt at disinfection is far more likely to be insufficient than complete, and if imperfect all or much of the trouble and expense has been thrown away. In all veterinary sanitary work. looking toward the extinction of a contagion, the work must be of a very radical nature, and if it fails in this it may be looked on as practically a failure. Restriction of the disease there may be without this, but extinction, never. With mere restriction outlay for prevention must go on forever; with extinction it will be brought to a final end.

To be effective, disinfection should be made the work of trained state officials. There is no more reason why this should be charged on the stock owner than that he should bear alone the money loss of his animals. Both are means of the extinction of the contagion with the one object of the public good.

G. NO PROVISION FOR SYSTEMATIC WORK.

The existing law fails to provide means for dealing with tuberculosis in all parts of the state, or to enjoin that the limited means provided shall be applied in a systematic manner upon any given area. Attention is therefore given to the herds whose owners make special application for inspection and those that are reported by others, and thus the inspectors are to-day in Westchester county, to-morrow in Erie, and the next in Tioga or Oswego. Single reported herds are dealt with and the great bulk of stock in the same district are passed over unnoticed. Is it to be wondered that complaints of partiality are heard? With the utterly inadequate appropriation this condition of things is perhaps inevitable, but it is certainly not the way to suppress the disease. A system that wipes out the disease on one farm, and at once leaves it to be reïnfected, from a diseased herd on the next place perhaps, is anything but commendable. If the means can be afforded to deal with the disease over the entire state, let this be done; but if not then let the appropriation be applied to a given geographical district and let this be purified as a whole and held so, while the good work is extended to other regions.

INSUFFICIENT INDEMNITY A FALSE ECONOMY.

In conclusion, it is right to emphasize the importance of a due consideration of property rights. Sanitary laws which in any way ignore or disregard the rights of property have within themselves the seeds of defeat. If within our municipal abattoir the butcher cannot conduct his business as well and economically as in his own establishment, he or his competitors will evade the law in some way. If the stock owner is not fairly reimbursed for his animals slaughtered and for other losses sustained for the protection of the public health and of the country's herds, unscrupulous men will find ample means of trading off the as yet incipient and occult cases of tuberculosis, and thereby planting the infection widely in new herds. Compensation must stop short of making the sanitary bureau a profitable customer for tuberculous animals at sound prices, but it must be so liberal as to enlist the ready coöperation of the stock owner in having every infected beast safely disposed of. Cases of advanced generalized tuberculosis may in all justice be listed at a low rate, as they are in every sense unfit to live, and are an expense, a danger and a nuisance even when dead. Cases too that have just been imported from another state or country and which are either manifestly diseased or taken from a tuberculous herd may fairly be excluded from indemnity and above all from a liberal indemnity. But in nearly every herd the majority of the stock condemned are to all outward appearances sound animals, and the owner has had no suspicion concerning them until this has been betrayed by the tuberculin test. But for that he would have gone on utilizing the animals in perfect good faith, and his customers would have received the dairy products in all confidence as to their wholesomeness. Had he wished to sell these animals for the dairy or for beef, he would have found plenty of purchasers at sound market rates. If the stock were thoroughbred and their progeny of a high prospective value he could have continued to breed from them for years since calves are rarely born tuberculous—not once in many thousand births even from tuberculous parents—and thus he might have largely profited by raising them on the milk of healthy cows. Then again in country districts the owner must bear the cost of disposing of the carcass by burning or burial in some place to which other animals do not have access. Further, the essential work of disinfecting the premises is at present put on the shoulders of the stockowner. Once more, if the stockowner is a dairyman, his trade is injured by the condemnation of animals in his herd. Customers will suddenly change to other dairies, creameries will be closed against his milk, and health officers are likely to quarantine the product, at least between the condemnation and slaughter. Apart from this his home supply of milk is lessened and to keep his customers he must go into the market and buy milk from others.

It is quite evident that in many cases of dairy herds and of valuable thoroughbred animals, an indemnity amounting to even the sound market value of the animals killed comes far short of reimbursing the owner for his actual losses.

These considerations should be taken fully into account, before adopting any proposal to fix a maximum sum or rigid rule for estimating values. The wording of the present law "the actual value" is perhaps as good as any, only provision should be made to have able and incorruptible appraisers, and a restricting clause might be introduced to prohibit or minimize awards for animals recently introduced into the State.

Disinfection should as a rule be done by State employes, thus relieving the stockowner of the expense and securing effective results. The disposal of carcasses may also in many cases be justly charged on the State. This cannot be an entering wedge for corruption, as excessive indemnity would be, and yet it would relieve the stockowners of an outlay that should be met by the public at large.

The disposal of infected manure and other products must be under the direction of the inspector, but must evidently be undertaken by the stockowner himself.

Points like the above cannot be too strongly insisted on, as they determine success or failure. In the extinction of cattle lung-plague in the United States the strict attention to such accessories proved the main factors in the speedy success. In Cook Co., Ill., I took charge of the work on behalf of the United States Government in April, 1887, and in July we had done away with the last acute case of the disease. But the whole city was systematically purged, stable by stable, no communication between sick and healthy was possible, condemned cattle were quickly disposed of, and in two weeks each owner received from Washington a check for the amount of his indemnity; thorough disinfection was affected by a government corps so that no stable ever needed to be disinfected a second time, and effective measures were taken to prevent the introduction of new cattle from infected localities. No state was ever so speedily cleared of this disease and the result must be altogether attributed to the carefulness of the methods, and their thorough application, and not least to fair indemnities and the promptitude of their payment. Great Britain has been struggling with the same disease for fifty years, and though she slaughters the sick, yet for lack of other efficient measures she cannot yet show a clean bill of health.

Bulletin 66. **May, 1894.**

Cornell University Agricultural Experiment Station.

AGRICULTURAL DIVISION.

TEST OF CREAM SEPARATORS.

—— BY ——

HENRY H. WING.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.

RECENT CHINESE VEGETABLES.

In recent years there has been a distinct infusion of Chinese and Japanese plants into our vegetable gardening. For the most part these plants are little known, even to the seedsmen who offer some of them as novelties, and it seems to be important that some definite account should be made of them before they become generally distributed and greatly modified, and while yet the history of their introduction is as little complicated as possible. It was some five years ago that the present writer took up their study, the results of which are presented in the following paper. It was at first thought that the botanical problems growing out of this study would be of easy solution and that little need be done in the final report but to narrate the behavior of the plants in the garden; but it was soon found that some of the types are almost inextricably confused, and that there are garden plants which have been long cultivated in this country which are undoubtedly of oriental origin, but the history of which is wholly unknown and which, furthermore, are not described and probably not mentioned in any American writings. The experiments with these Chinese vegetables, therefore, have enforced upon me again the importance of critical studies of garden plants—to which few American students have given their attention,—not only for the purpose of arriving directly at economic results, but quite as much for the elucidation of the broader problems of the variation of plants under new conditions of life and for the discovery of the means by which they may become widely distributed over the face of the earth and in the very centers of civilized countries without attracting a passing notice from naturalists.

These Chinese vegetables which I have here described, might be thrown into two categories with respect to their introduction into North America. The first group would include some of the better known species, like the so-called cabbages, which have been in the country some years and have been regularly sold by reputable seedsmen both of Europe and America. The second group would include those which are brought in by the Chinese gardeners about some of the great cities, and which are almost unknown to the American planter or catalogue reader. I have taken some pains to secure these plants of the celestial gardeners, and my experiences have been often better suited to narrative than to instruction. The Chinese gardener, upon his scrupulously tilled bit of land, is suspicious of an intruder and he hesitates to part with his seeds for fear of disastrous competition ; but we have, first and last, I think, been able to secure and grow nearly every vegetable which is grown by the Chinese about New York and Boston. And there are few of them which are worth transferring to our gardens.

But with the Chinese names and descriptions, things have not gone so smoothly. The Chinese language abounds in dialects and the gardeners whom I have visited either could not or would not write the Chinese characters ; or, if they had, matters would not have been simplified. I finally received great aid from Mr. Wah Hang, of Boston, upon whom I am glad to place the responsibility of most of the Chinese characters in the following pages. I have also had the advantage of valuable suggestions from Mr. L. Wing, of the Chinese Consulate in New York City.

I. CABBAGES AND MUSTARDS.

Pe-Tsai. (*Brassica Pe-Tsai.*)

The Pe-Tsai, or Chinese cabbage, is no longer a novelty in American gardens, although it does not appear to be well known and its merits are not understood. Its cultivation and peculiarities were described in France so long ago as 1840 by Pépin, who says that, while the plant had been known in botanic gardens for twenty years, it was brought to notice as a culinary vegetable only three years before he wrote. It appears to have attracted little attention in Europe until very recent years, however, and it is still included in the second edition of Paillieux & Bois' "Kitchen Garden of a Virtuoso,"* 1892. It began to attract attention in the United States probably about ten years ago.

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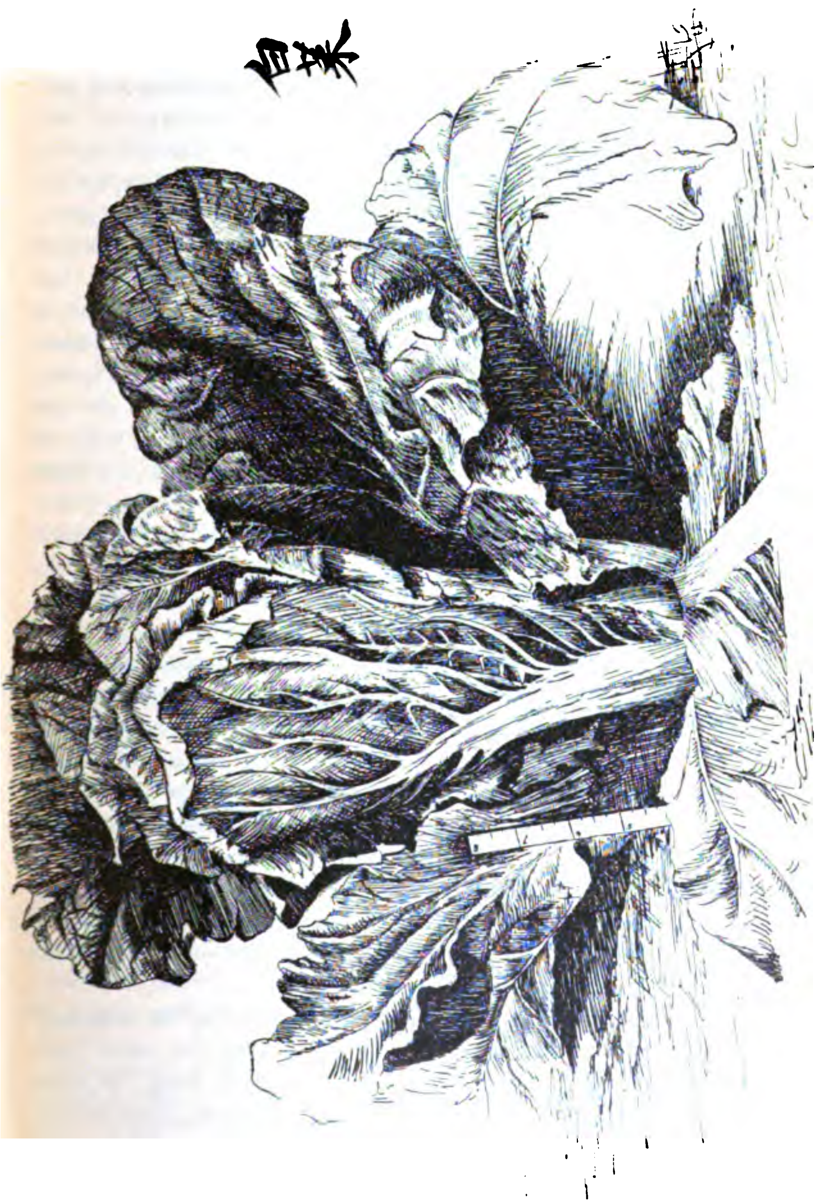
* Le Potager d'un Curieux, Paris.



Pe-Tsai, or Chinese White Cabbage.

The Pe-Tsai (or " white cabbage ") of the Chinese, is properly an annual plant, which has much the habit of a Giant Cos lettuce. The illustration on page 179 shows an excellent specimen, when ready for cutting. A Japanese drawing of the plant is shown upon this page. The name of this particular Japanese variety, as written in the characters at the right, is Santo-Tsai, a variety which we have grown three or four years. The characters at the bottom explain that it was raised in the Mita gardens at Tokio.

Santo-Tsai, fram a Japanese drawing.

The Pe-Tsai needs a moist and cool soil for its best development. If the plants are left too long in a seed-bed they tend to run to seed, and they do the same if set upon a hot and dry soil. The plant is nearly as hardy as the ordinary cabbage, and takes advantage of the cool weather of September to make its best leaf growth. We have usually sowed the seeds in June in a seed-bed, transplanting the plants before they begin to crowd, and procuring the heads in September and October ; but if a cool and uniformly moist, generous soil can be provided, the plants may be started late in July or in August with good results.

The head of the Pe-Tsai is never solid like that of the cabbage, but is rather a long and loose roll of soft leaves, the inner ones becoming blanched and very crisp. In order to keep the head compact and tender, its top should be tied together, when nearly mature. An average core, or compact portion of the head, will measure ten or twelve inches in length, by a third or half as great diameter. The one illustrated on p. 179 weighed 3 lb. 6 oz. The head is eaten in the same manner as ordinary cabbage, and it affords a very excellent dish. It is somewhat milder and sweeter than the cabbage. In China, I am informed, the plant is often served uncooked, being shredded with sugar and vinegar. If well grown, it is excellent eaten raw.

We rarely secure heads from all the plants. In fact, in making many experiments, we have only once secured what could have been called a good crop, and in this instance the plants grew upon a moist or even wet clay loam. A correspondent in China states that the plants need to be well watered. But I am convinced that some of our unsatisfactory crops are to be charged to poor seed. There is no systematic attempt to grow the plant for market, and therefore little selection is practiced in the choice of plants and strains for seed-bearing; and as the plant runs so quickly to seed in dry soils, it is easy for the stock to soon deteriorate. A Japanese horticulturist, to whom I stated my difficulties, confirmed my suspicions by saying that the grade of seeds has a marked influeuce upon the crop.

We have grown this interesting cabbage from several sources, and we have found little variation in the form and type of head, although the foliar and some other characters of the plants are perplexingly variable to one who desires to study them with reference to their botanical features. The Shantung Cabbage,* grown from seed furnished by the Royal Gardens at Kew, England, is somewhat dwarfer, but it does not appear to differ in other respects from the ordinary type. Another variety, which we have obtained from New York Chinamen, is called *Luon*. The Chinese cabbage is always distinguished from related species by its very wide and winged petioles or leaf-stalks, which remind one strongly of the leaf stalks of the salad beet or Swiss chard.

Pe-Tsai is probably a native of China, although its aboriginal form does not appear to be understood. It is much cultivated there, and also in Japan. Professor Georgeson* makes the following account of it in Japan:

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* Introduced in England in 1887. "It grows in the north of China, is lettuce-shaped, and weighs from 5 to 8 lbs. . . . It is an autumn cabbage, should be planted about 18 inches apart, thrives best with moisture, and in Shantung is watered every day; there the seed is sown in June."—*Kew Bulletin, May, 1888, 137.*

"No other vegetable of this class is so universally grown, or is represented by so many varieties. It is a kind of rape which has been transformed by cultivation. Certain varieties of it are grown only for their seed, from which an oil is expressed, formerly much used as lamp oil. This class of illuminating oil is, however, rapidly passing out of date, its place being taken by American kerosene. . . . . The term cabbage is a misnomer, as its resemblance to that vegetable is quite remote. The plants are merely bunches of large, smooth, more or less spreading leaves, with broad fleshy midribs. They do not bear their leaves on a well defined stem, as do the cabbage, kale, etc., but look more like the Cos lettuce, the leaves having their origin at the surface of the ground. They are usually cultivated as a fall crop and grow very rapidly, some varieties attaining a height of two or three feet in two months from the seed. The seed is usually sown early in September. When large enough, the plants are set out in rows like cabbage, the distance varying with the size of the varieties. For rapid growth they require a rich soil, and good cultivators stimulate their plants by applications of liquid manure every eight or ten days. By the end of October the crop is ready for use and it is cut and marketed before frost. In taste, all varieties are much alike. They have the characteristic flavor of the Cruciferæ in a wild form. This flavor is improved by blanching, which is commonly done either by simply tying up the leaves or by heaping the earth up about them. Thus treated, the leaves make a crisp and palatable salad. They are also boiled for greens, and enter into the composition of many dishes. Why might not this class of cabbage find similar uses in this country? It would especially compare favorably with the collards so largely grown for the southern markets, and which are merely varieties of non-heading cabbage of tough fibre and strong taste. Some of the large varities might also be of value for stock feed.

"This species is not hardy; it must be harvested before frost. It is, in fact, chiefly grown for winter use. For this purpose it is packed closely in tubs, with thin layers of common salt scattered through the mass. It soon undergoes a fermentation, which converts it into a kind of sauerkraut called *Natsuki*, which can be kept all winter and drawn upon at pleasure. There are many varieties, the following being some of the leading ones: *Hakusai*, *Shirakuki-na*, *Tojin-na*, *Santo-sai* (see cut, p. 180), *Mikawashima-na*, *Komatsu-na* and *Uguishu-na*."

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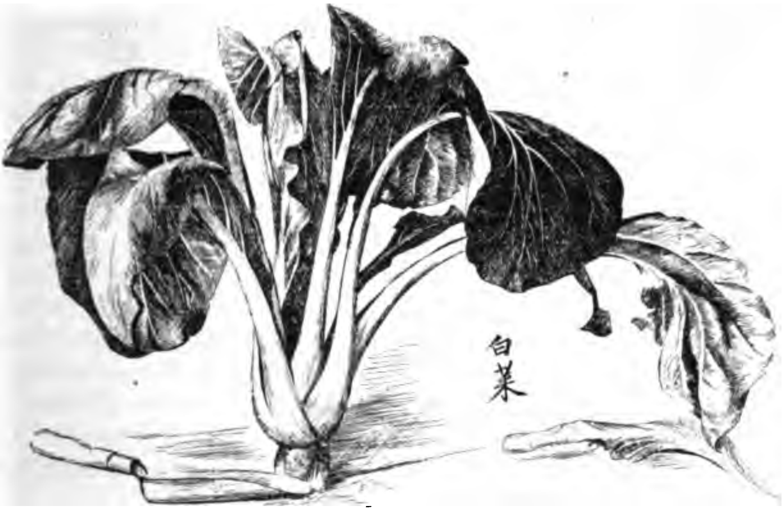
*Amer. Gard. xii. 652 (Nov. 1891).



Pak-Choi.—(*Brassica Chinensis.*)

The Pak-Choi*, commonly called Chinese cabbage and frequently confounded with the Pe-Tsai and apparently always (but, I believe, erroneously) referred to the same species, is a vegetable which never forms a head, and which appears to be normally biennial, although it freely runs to seed the first season if left in the seed-bed or grown upon dry soils. The engraving above is an excellent illustration of a well grown plant. Unlike the Pe-Tsai, the leaves are borne upon long and marginless stalks, and they spread in all directions, like a turnip top. These leaf-stalks are light colored, sometimes almost ivory white and celery-like, and are

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*The word for "greens" is spelled *Choi* and *Choy*, when rendered in English characters, but Mr. L. Wing, of the Chinese Consulate, New York, tells me that the former spelling more nearly conforms to the Cantonain pronunciation.

the most edible portion, being cooked and served after the manner either of cabbage or asparagus. The entire foliage is cooked as "greens," however. The plant is curious and affords an acceptable variety for the kitchen-garden, but I cannot see that it is destined to become even an important secondary vegetable in America. The plant requires a somewhat longer season than the Pe-Tsai.

TUBEROUS ROOT OF PAK-CHOI.

I have said that this plant is apparently normally biennial. Most of the plants, if given cool, moist soil, tend to make a turnip-like root, like that shown in the engraving above. These roots are not unlike turnips in flavor. A patch was sown May 23, 1893, to Pe-Tsai and Pak-Choi, the plants not being tansplanted. On November 19, when the last notes were taken, the Pe-Tsai plants had all perfected seeds and were dead, but most of the Pak-Choi plants were still growing, and had thick tuber-like roots.

This plant is so uniformly associated with Pe-Tsai in horticultural writings, that I am unable to separate its individual history. It is undoubtedly native to China. There are many forms of it. We have grown it in two varieties from Japanese sources, and from the Chinese about New York we have it under the names *Bok-toi-moi* and *Choi-toi-moi*.

California Peppergrass. (*Brassica Japonica*). PLATE I.

In 1890, John Lewis Childs introduced the California Peppergrass, with the following description: "Some years ago, we received from a customer a sample of seed which was called California Peppergrass. It was recommended as being extra fine for salads, dressing and garnishing, and unlike anything else known. We find it a very beautiful and valuable thing, and unlike anything else of the sort. It seems to be halfway between a cress and a mustard. Its leaves are long and narrow, deeply laciniated, fimbriated and crinkled, making it one of the prettiest green foliage plants we ever saw. To the taste the leaves are sharp, and have much the flavor of peppergrass. It is excellent when mixed with lettuce or other salads to which it imparts a very fine flavor. For garnishing there is nothing more beautiful. It grows very quickly, and to keep up a succession all summer several sowings must be made. We think its flavor much improved if bleached a few days before cutting by covering with boxes or boards." Our own experience with the plant confirms the above account of its behavior. It is one of the best plants for early spring "greens," as it grows very quickly, is hardy, and it makes a very compact tuft of crisp and beautiful leaves. The illustration in Plate I shows a plant when in condition for the table, but the specimen from which the photograph was taken was wilted, so that the compact growth of the young plant is not apparent.

I recognized this plant as a probable cut-leaved and crinkled form of a garden mustard which I had known from boyhood, but the botanical position of which I had never been able to determine. There is a tradition in the family that the seed of this mustard was brought into western Michigan in the early days from Maryland. In my father's garden, the plant has maintained itself for at least twenty-five years, coming up early each spring from self-sown seed. The crisp tufts of May herbage have always been a favorite for spring "greens." I have also found this plant, with leaves almost as much cut as in the California Peppergrass, in a garden at Lansing, Mich., and John K. Small has collected the same form "about the neglected garden of Wells Miller, on the summit of White Top Mountain, Washington Co., Virginia."*

The plant appears, therefore, to be widely distributed in this country, and the wonder is that neither American horticulturists nor botanists appear to have made any record of it; and I am not able to trace it in the garden literature of Europe. It appears to be the *Sinapis Japonica* of Thunberg, and a native of Japan or China; and I am led the more confidently to refer it to this species as Mr. Wah Hang says that he recognizes the form cultivated as California Peppergrass, to be the *I-how-toi* of the Chinese. In the Japanese botanical serial, *So Mokou Zoussetz*, vol. xi. folio 38, is a good figure of the California Peppergrass form, under the name of *Sinapis Japonica*, or *Chirimen-na* of the Japanese gardens. I do not know how extensively this vegetable is cultivated either in China or Japan. Professor Georgeson* speaks of the "*Midzu-na*, still another species which perhaps furnishes the most favorite varieties,'' and says that the plant is *Sinapis Japonica*. "One of these varieties which originated in Yamashiro, is called *Sensuji*. It is remarkable for the large number of leaves produced by a single root, and the leaf is narrow and deeply and irregularly cut. All these mustards are sown in the fall and used for greens in the winter, being gathered as wanted. In cold situations I have often seen the rows partially protected by leafy bamboo branches stuck thickly in the ground. The market gardeners on the east side of Tokio make a specialty of this winter crop." But the Japanese serial quoted above, refers (folio 33) the *Midzuna* to *Sinapis Chinensis* of Linnæus, quite a different plant, in my opinion, from *S. Japonica*, although Professor Georgeson unites the two in his account.

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* Specimen in Torrey Herbarium, Columbia College.

Chinese Mustard. (*Brassica juncea.*) PLATE I.

Under five names we have grown mustards which appear to be varieties of one species. These plants are the Chinese Broad-leaved mustard (Thorburn) and the *Moutarde de Chine à feuille de Chou* (Vilmorin), which are identical; Chinese mustard (Thorburn, Rawson, Vilmorin); Brown mustard (Rawson); and *Brassica rugosa* from the Royal Gardens, Kew, England. The upper engraving in Plate I is an excellent likeness of the form sold as Chinese mustard by Vilmorin. This is the *Choi-toi* of the Chinese. The plant is very rank and coarse in its growth, the large rugose and roughish leaves often standing two feet high in moist soil. But even in this rank state, we have found the plant to have distinct value as a pot-herb. It cooks tender, and has a

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*Amer. Gard. xii. 653.

arm, half-pungent flavor which is very agreeable. Like other
ustards, if these large leaves are desired, the plant should be
ven a cool soil and the best growth should be expected in spring
fall. The photograph in Plate I was taken on the 21st of Oc-
ber. We have found this plant excellent for forcing, for winter
reens" (see Bull. 55, p. 143).

Brassica juncea, as now accepted by botanists, is held to include
great variety of forms. It is native to tropical and temperate
sia, and is widely cultivated in the Old World. According to
ooker and Thomson,[*] it affords the Soorsa mustard of India,
hich is cultivated for oil and burning, and rubbing the body in
ness. Professor Georgeson speaks of its cultivation in Japan as
llows:[†]

" *Taka-na*, *O-garashi.*—This species is not a native of Japan.
is indigenous to Africa and China, from which latter place it
s doubtless been introduced. It is a large plant, as is indicated
the native names, one meaning 'tall greens' and the other
arge mustard.' It is hardy, and is usually sown in the fall, in
ws two feet apart, for winter use. The leaves are large, spatu-
te or obovate, the radical ones often a foot long, the lower por-
on of the margin dentate, and the upper portion entire or slightly
nuate. It is highly esteemed for salad, and is used all winter
ng. Certain varieties are also grown for the seeds, which are
ed both for condiment and as a source of oil. It is said to be
ltivated in all parts of India for the seed, which is exported
nder the name of Sarepta mustard seed."

Tuberous-Rooted Chinese Mustard. (*Brassica napiformis*).

This vegetable appeared in France in 1882 from seeds sent by
r. Bretschneider, of the Russian legation, Pekin.[‡] It was offered
American seedsmen as early as 1889.[||] The plant is a bien-
al, with thin bluish foliage, and a small tuberous root like a
nical turnip. These roots, which reach a diameter of three or

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[*] Journ. Linn. Soc. v. 170.

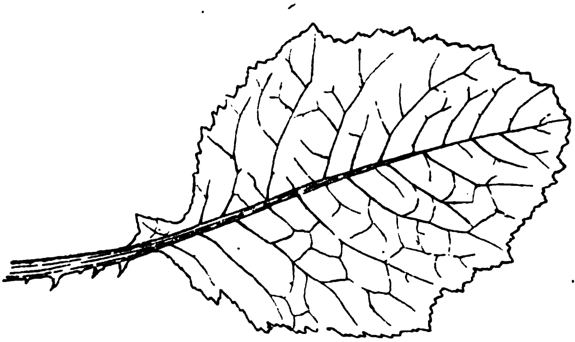
[†] Amer. Gard. xii. 653.

[‡] Paillieux and Bois, Le Potager d'un Curiex, 2d ed. 372.

[||] Annals of Horticulture, 1889, 121.

four inches, are scarcely distinguishable from white turnips in appearance, texture and flavor. I have not yet discovered sufficient merit in the plant to warrant its general cultivation in this country. In China the tubers are used as a winter vegetable, the seeds being sown in summer.

The plant is native to China. It does not appear to have been brought to the attention of botanists until Bretschneider published an account of it in a French journal in 1881. Paillieux and Bois regard it as a variety of *Brassica juncea*, to which the Chinese mustard belongs, but it is very different from that plant, and I am forced to consider it a distinct species. It is more nearly related to Pak-Choi than to any other plant which I know, and it may have sprung from the same species; but it is clearly distinguished by its sharply toothed leaves, one of which is shown in the accompanying figure.



Lower Stem-leaf of Tuberous Rooted Mustard.

Botanical Characteristics of These Cabbages and Mustards.

In common with all members of the genus Brassica, or Cabbage and Mustard tribe, these Chinese plants are much confused respecting their botanical characters. Recent writers* have referred all the Chinese Cabbages to *Brassica campestris*, the Ruta-Baga; but one who studies the plants carefully both from herbarium and living specimens, cannot long hold this opinion. The genus Brassica divides itself naturally into two groups,—the cabbages and rape, characterized by thick leaves, very glaucous-blue herbage and long flowers which are creamy white, and the mustards, with thinner and green or lightly glaucous herbage and small bright yellow flowers. The Chinese cabbages belong to this latter group rather than to the former. Their flowers are those of the mustards, and I have no hesitation in removing the plants from *Brassica campestris*.

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* See, for instance, Kew Bulletin, May, 1888, 138; Forbes & Hemsley, Journ. Linn. Soc. xxiii. 46.

There is even good reason for separating the two types of Chinese cab-ge—the Pe-Tsai and Pak-Choi—into two species, for they differ widely in eir leaf characters and pods; and the former is truly annual, while the tter is evidently normally biennial. The Chinese cabbage has been under-ood to be the *Brassica Chinensis* of Linnæus, but Linnæus' description not explicit and it does not fit the Pe-Tsai, although it designates fairly ell the characters of Pak-Choi. The remarkably broad-winged flat petioles ould not have escaped Linnæus' description if he had had the Pe-Tsai pe before him, and his comparison of the foliage to that of the cynoglos-m suggests Pak-Choi rather than Pe-Tsai. Louriero, however, explicitly scribes the Pe-Tsai as *Sinapis Pekinensis* var. *Pe-Tsai*, and I have raised is variety to specific rank under Brassica, the genus with which Sinapis is w united by most botanists. I have ventured to use Linnæus' name for e Pak-Choi, although it is impossible, without an examination of his her-rium, to detemine the plant which he had in mind.

The tuberous rooted Chinese mustard is regarded as a variety of *Brassica ncea* by Paillieux and Bois, but it is widely different from that plant, not ly in its biennial character but in distinct leaf characters and glaucosity. is most closely allied to Pak-Choi, but the leaf characters in the two are unlike that I have felt obliged to regard them as distinct species.

The five types of Chinese cabbages and mustards here considered may be istinguished as follows:

* *Plant potentially biennial (i. e., the root hard and thickened, often dis-nctly tuberous); foliage firm in texture.*

BRASSICA CHINENSIS*, Linn. Amœn. IV. 280 (1759). **PAK-CHOI**, etc.

adical leaves numerous and large, glossy-green, obovate or round-obovate general outline and entire or obscurely wavy or crenate, tapering into a stinct thick petiole, which is not at all or very little margined or sometimes ith a few leaf-like lobes; flowering stem and its leaves more or less glaucous, e leaves obovate or oblong and clasping; flowers light yellow; pods large d long and rather slender (about 3 in.) and firm, tapering into a cylindrical d sharp beak a half inch long.

Linnæus' description of the species is as follows:

"Brassica (chinensis) foliis ovalibus subintegerrimus, floralibus amplexicaul-us lanceolatis, calycibus ungue petalorum longioribus.

"Habitat in China. Dn. Osbeck attulit semina.

"Descr Folia oblonga seu ovalia, simillima cynoglosso, obtusa sed glabra; ulina amplexicaulia, oblonga, integerrima. Flores, ut in Brassica oleracea-tei. Calyx unguibus petalorum longior, unde hians and interpetala promi-ens. Stamina longiora. Siliquæ parum compressæ."

2. **BRASSICA NAPIFORMIS. TUBEROUS-ROOTED CHINESE MUSTARD.**

Sinapis juncea, var. *napiformis*, Paillieux and Bois, Le Potager d'un rieux, 2nd ed. 372 (1892).

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*Sinapis Chinensis of Linnæus, is a different plant.

Radical leaves much less numerous, the blade thin and oval in outline and on long and slender, slightly feathered petioles, sharply and irregularly toothed, with a thin bloom; lower stem leaves much like the radical ones, but the uppermost oblong-lanceolate and clasping; flower stems (very tall) lightly glaucous-blue, the flowers bright yellow; pod much as in Pak-Choi, except that the beak is abrupt and very slender.

***Plant truly annual; foliage loose and soft.*

3. BRASSICA PE-TSAI. PE-TSAI, etc.

Sinapis Pekinensis, var. *Pe-Tsai*, Louriero, Flora Cochinchina, 400 (1790).

Radical leaves numerous and large, light colored, oblong or obovate-oblong, soft and crinkled and very veiny, the margins wavy, the wide lower portion comprising a flat ribbed petiole 1 to 3 in. wide which is margined by a wavy or notched wide and thin wing; lower stem leaves notched or crinkled-margined, the upper oblong-oval or oblong-lanceolate, all sessile and clasping and more or less glaucous; flowers light yellow; pod short (about 1½ in.) and thick, softish, much broader and softer than in Pak-Choi, very gradually narrowed into a cone-like short point.

Louriero's description of the plant is as follows:

"Sinapis Pekinensis. var. Pe tsái. a Cai bén.

"Differ. spec. sin. foliis turbinato-ovatis, integris, crispis: petiolis subplanis, latis: silisquis glabris, planinsculis.

"Hab., et notae. Caulis annuus, 2 pedalis, erectus, crassus, teres, glaber. Folia radicalia turbinato-ovata, integra, serrato-runcinata, crispata, glabra, flavescentia, tenerrima: petiolis sub-planis, latissimis, albis, sulcatis, semiamplexicaulibus: caulina conica, sessilia integerrima. Spicæ solitariæ, longissimæ, patentes. Calycis foliola 4, oblonga, obtusa, erecta, lutea. Corolla similiter lutea, 4-petala, patens. Siliquæ lineares, compressæ, glabræ, 2-loculares: seminibus globosis, rufis.

"Habitat Pekini culta, ubi omnium optima. In Cochinchinâ altius crescit, inferior qualitate. In Lusitania satam, et plantatam servo, sed quotannis in peius degenerantem.

"Observ. Attendens ad varietates Brassicæ oleraceæ in Europa cultas, et facie inter se valde differentes dubitare cæpi, non omnes istæ sinapis plantæ dici etiam debeant varietates, non diversæ species?

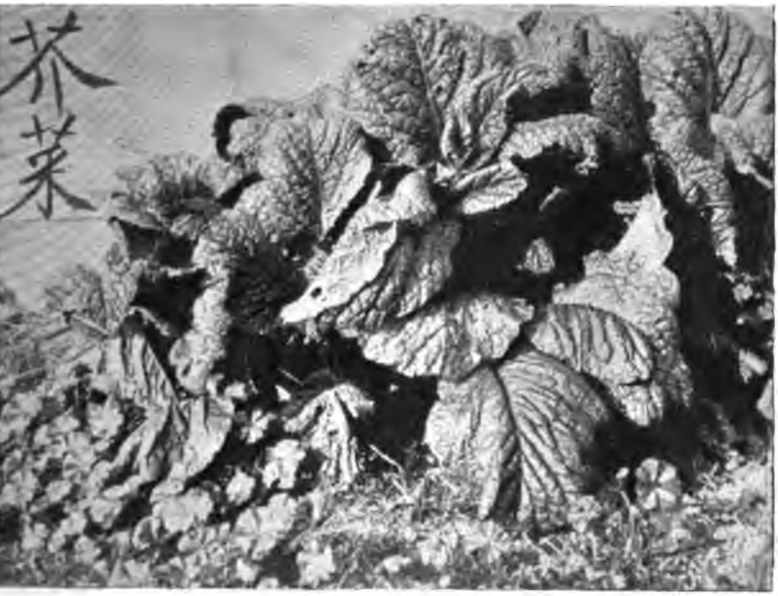
Virtus. Fere eadem, quae praecedentium, sed debilior."

4. **BRASSICA JAPONICA**, Siebold; Miquel, Prolusio Floræ Japonicæ, 74 (1865–6); Georgeson, Amer. Gard. xii. 653 (1891), in part. *Sinapis Japonica*, Thunberg, Flora Japonica, 262 (1784). CALIFORNIA PEPPERGRASS, etc.

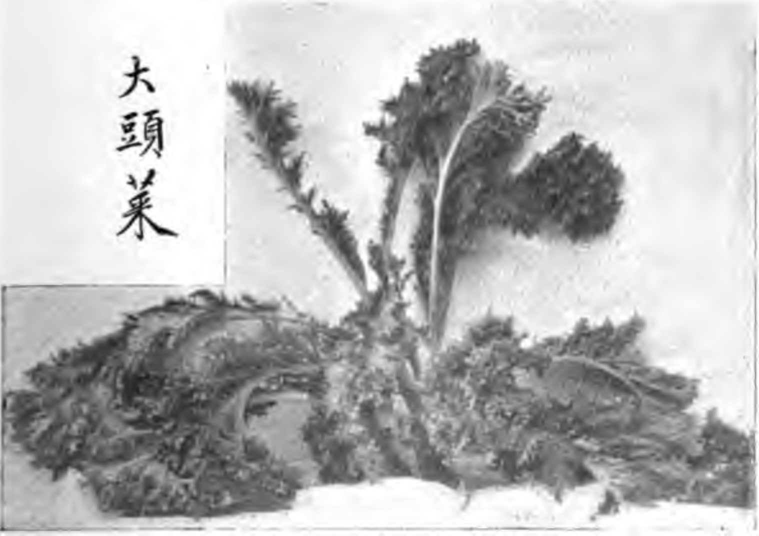
Radical leaves rather many, oblong, or oblong-obovate, the margins either crisped or the whole blade cut into many fern-like curled and crisped divisions; stem-leaves toothed or cut, all petioled, usually very glaucous, as well as the stem; flowers small, yellow; pods much smaller than in the preceding three species, with a gradual slender beak.

The *Sinapis Japonica* of Thunberg is undoubtedly the plant which we are considering. There is some question, however, if the *Brassica Japonica* of

PLATE I.



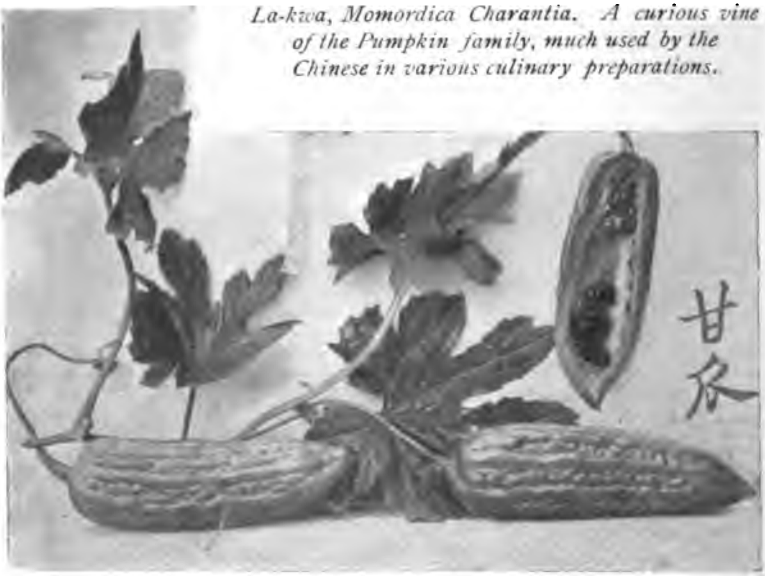
Chinese Mustard.—Brassica juncea.

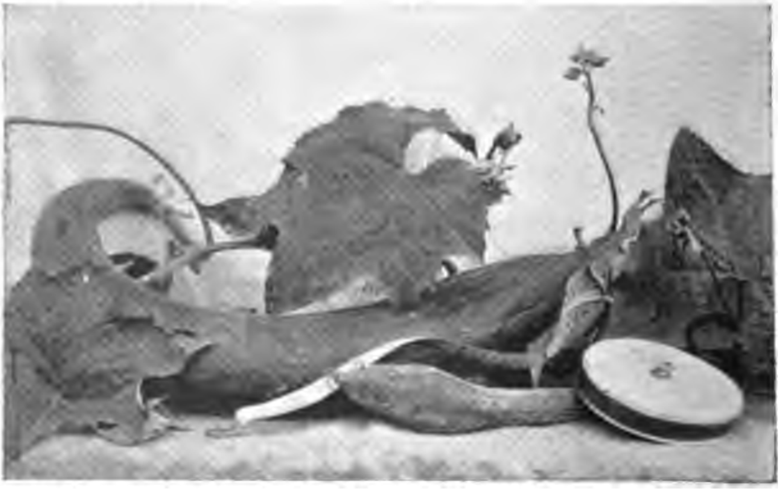


California Peppergrass.—Brassica Japonica.

PLATE II.

La-kwa, Momordica Charantia. A curious vine of the Pumpkin family, much used by the Chinese in various culinary preparations.





Sua-kwa, or Dish Cloth Gourd.—Luffa cylindrica.

bold is the same. This latter plant is known only by the following inci- tal reference to it by Miquel:

' *Brassica Japonica* Sieb., in Europa e seminibus Japonicis educta, cum *api Japonica* Th., floribus congruit, diagnosin *S. auriculatae* DC., haud udians, nobis ob sp. incompletum nimis incerta."

t has seemed better, however, to accept Siebold's species to be the same Thunberg's—inasmuch as there is no evidence that it is not the same— n to propose a new name for our plant.

5. **BRASSICA JUNCEA**, Coss. Bull. Soc. Bot. France, vi. 609 (1859).
Sinapis juncea, Linn., Sp. Pl. 668 (1753).

adical leaves generally abundant and often very large, oval or oboval in line, the blade angled or toothed, tapering into a narrow petiole which erally bears leafy appendages; lower stem-leaves more or less toothed and iolate, the upper ones oblong or oblong-lanceolate and entire and closely sile or clasping; flowering stems and leaves more or less lightly glaucous; wers bright yellow; pod slender, of medium size, tapering into a short k.

This much abused species is held by Hooker and Thomson (Journ. Linn. . v. 170) to include a great variety of forms, as *Sinapis lævigata*, Linn., *integrifolia*, Willd., *S. ramosa*, *rugosa*, *patens*, *cuneifolia*, Roxbg., *S. ceolata*, DC., and others. There are two types of it in cultivation in our dens, one with the radical leaves somewhat sharply toothed and nearly ooth below (comprising the Kew *Brassica* (or *Sinapis*) *rugosa*), the other h root leaves obtusely toothed and spinescent on the veins below (compris- Chinese mustard, Chinese Broad-leaved mustard and Brown mustard). næus founded his *Sinapis juncea* upon a figure in Hermann's Paradisus ermann, Paradisus Batavus, t. 230. 1705), which represents a plant very e the former type mentioned above, and which Hermann described as uce-leaved.

II. CUBURBITS.

Zit-kwa,* *or Chinese Preserving Melon.* (*Benincasa cerifera*).

This plant appears to be a common inhabitant of Chinese gar- ns. Under the name of Chinese Preserving melon, it was in- duced in 1892† by John Lewis Childs. I am told that in the inese quarter of San Francisco it is known as Chinese water- lon. The plant is one of the melon family, and is well known a garden esculent in India, where it is native, and in other iatic countries. The aspect of the vine is not unlike that of a

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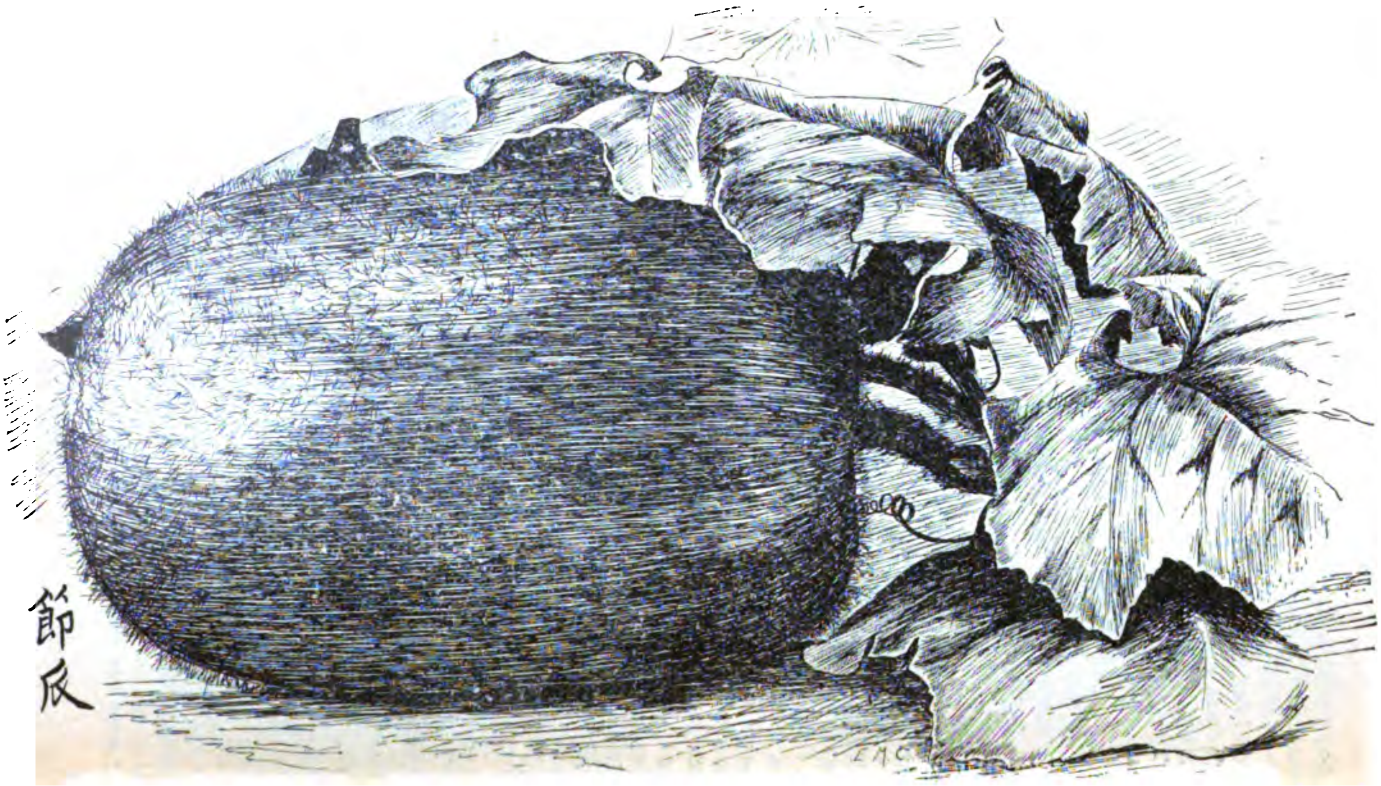
Mr. L. Wing regards *Kwa* as the best spelling of the Chinese word for ash or gourd. Bretschneider, however (*On the Study of Chinese Botani- Works*, etc.), uses *Kua*. It is sometimes spelled *qua*.

Annals of Horticulture, 1892, 181.



Zit-kwa, or Wax Gourd. Also known as Chinese Preserving Melon and Chinese Water Melon.—Benincasa cerifera.

ık and hairy muskmelon vine. The fruit is round or oblong, th a solid white flesh and small white seeds. The exterior is eenish and hairy, and covered with a film of white wax-like bstance (whence the name *cerifera* or *wax-bearing*). It ordin- ily reaches a length of ten to fifteen inches. In the books, the uit is known as the wax gourd. In India, according to Fir- nger,* it is called pumpkin and white gourd by Europeans. ıe culture is similar to that of the muskmelon. I do not know w the Chinese use this fruit. Vilmorin† writes that the fruits e eaten the same as squashes, and that the character of the sh is intermediate between that of the squash and cucumber. illieux and Bois‡ say that it is "prepared like the cucumber, which, to our taste it is much preferable." I have been una- e to relish the fruit when uncooked, but made into preserves or eet pickles it is one of the best of all subjects for the purpose, d it is worthy general cultivation for such culinary use.

La-kwa. (*Momordica Charantia.*) PLATE II.

This plant is well known as a condiment and ingredient of rries and other table preparations, in the tropics, especially of e Old World, where it is native. It is also grown as an orna- ental vine, and for this purpose is sold by American seedsmen, ong with the allied species, *Momordica Balsamina* or Balsam ple. The plant is a vine, reaching a length of ten feet, and en covering the ground with a mat of attractive herbage and llow, soft flowers. The leaves are cordate-ovate in general out- e, but are cut into five more or less toothed lobes. The fruit the common form is oblong, six or seven inches long and cov- ed with wart-like tubercles. This fruit is borne upon a slender m of its own length, or more, and which bears a small leaf-like pendage at some distance back of the fruit. This appendage entire or continuous in outline in this species, but in the true lsam Apple (*M. Balsamina*) it is distinctly toothed. The fruit the La-kwa splits into three divisions at maturity, disclosing ıny rounded, bright scarlet bodies. These bodies are edible, and they comprise a pulpy mass (known to botanists as an aril) with a flat, squash-like, white or brown seed in the center. The seeds are curiously carved or marked upon the sides, and I have received them for planting, under the name of "Art Pumpkin."

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* Manual of Gardening for India, 3d ed. 126.

Les Plantes Potagères, 2nd. ed. 37.

Le Potager d'un Curieux, 2nd. ed. 44.

This plant is a favorite with the Chinese, but I doubt if it will meet any considerable favor with Americans as an esculent. A writer in *Garden and Forest*[*] calls it *Foo-qua*; but I have never heard this name applied to it. The name *La-kwa* is said to mean "bitter squash." The bitter rind is dried as a medicinal preparation. The fruit is prepared in various ways, when immature. The seed masses are dried, and in this condition are mixed with meat and are used in preparations of appetizers. The plant is also commonly cultivated in Japan,[†] under the names *Tsuru-reishi* and *Niga-uri*. The various methods of preparing the fruit for table use in China, are given as follows by Edward Wilmann in a foreign publication: [‡]

"This fruit, which attains an average length of three to four inches, is always gathered and used before it is ripe. When ripe it is useless from a culinary point of view. Some prefer it when it is still tender, while others do not relish it before it possesses some consistency. In either case, it is in good condition until it matures. For the table it is prepared as follows:

"*In salad.* The fruit is cut lengthwise into halves, and the seeds are removed. These two parts are then put into a sauce made of vinegar, olive oil, ginger, garlic, all-spice, salt, etc. It is customary to add to this also some cucumber, cabbage, carrot, mango, etc.

"*Pickles.* After having removed the seeds, the fruit is cut in circular slices, and is then seasoned with citron juice, all-spice, ginger, etc.

"*In cari.*[||] The fruit, having been cut into two pieces, is prepared by boiling with fresh or salt bacon, or with fresh or salt sh. *Cari* may be added if desired, but the common southern ondiments are in general use.

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[*] E. T. Lander, "Chinese Horticulture in New York," *Garden and Forest*, i. 483.

[†] Tamari, Trans. Amer. Hort. Soc. iv. 79; Georgeson, Amer. Gard. xiii. 526 (with illustration).

[‡] Paillieux & Bois, Le Potager d'un Curieux, 2d ed. 335.

[||] Cari is a condiment powder made of all-spice, curcuma, and other spicy powders.

" In India the fruit is sliced and then fried. It is necessary, owever, to boil it in water first, in order to remove all bitterness."

Sua-kwa. (*Luffa cylindrica*). PLATE II.

絲瓜 THIS plant we have grown from several sources, and under a variety of names, as Dish Cloth Gourd from American seedsmen, *Naga ito-uri* from Japan, and *Luffa Fabiana*, *L. Japonica* and *L. noctiflora odorata*.[*] I have not seen this lant in Chinese gardens, but Mr. Wah Hang tells me that it is well nown in China, where it is called *Sua-kwa* or " water squash." It ; widely distributed in all tropical countries, and its nativity is ncertain, but it is probably indigenous to Asia. It is a cucumber-ke vine, bearing slender cylindrical curved fruits which, in our ardens, reach a length of one to two feet, although in warmer ountries the fruits of some varieties are said to reach nine feet in ength. The fruit of this species is well shown in the lower figure 'late II. It is destitute of ridges, and this character distinguishes : from *Sing-kwa*, which is described in the following pages. There re also good leaf characters to separate the two. This plant, the *ua-kwa*, has distinctly 5-lobed leaves, while the other has rounded nd angled or shallow-lobed leaves. These characters are all adnirably drawn in an article and illustration by Professor Georgeson n the *American Garden* for September, 1892, but the plant is reerred to the wrong species.

The fruit is eaten before it is mature, either sliced like cucumer, or in soups, or cooked like squash. In Japan, according to 'rofessor Georgeson, the young fruit is sliced and dried and thus reserved for future use. The fibrous interior of the mature fruit as a sponge-like texture, and when cured can be used as a sponge r towel, for which purpose it is frequently sold in our stores. 'he chief value of the plant in this country is in this spongeike fibre, and it is worth growing in for ornament ; but I doubt if t will ever become prominent as a food-plant. The plant requires a long season, and it should be started early and placed upon a warm quick soil. Like the cucumber and melon, the luffas are tender and should not be placed in the field until frosty weather has passed.

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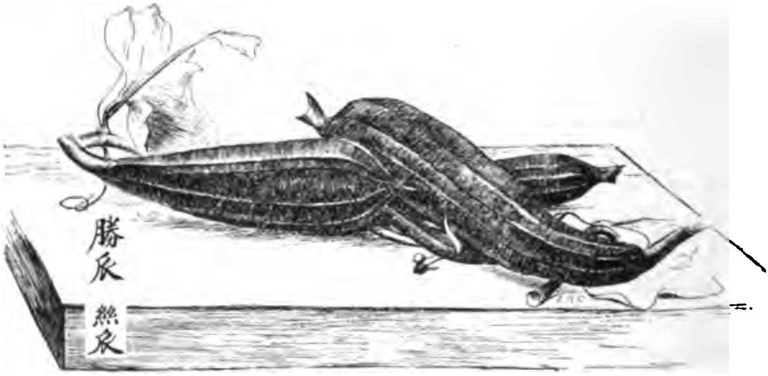
[*] **Botanical synonyms of this species are the following, amongst others** ***.uffa Ægyptiaca, L. Petola, L. striata, L. Veitchii.***

Sing-kwa. (*Luffa acutangula.*)

This plant differs from the preceding in bearing a ten-ribbed fruit, as shown in the illustration (below), and leaves which are rounded in outline and only slightly lobed. It is in common cultivation by the Chinese about New York, to whom it is known as *Sing-kwa*, or "hairy squash," although I do not know why the name is applied to it unless in reference to the somewhat pubescent stems, although it does not differ perceptibly in this respect from the *Sua-kwa* just described. This plant, like the other, is widely distributed in the tropics and is known under a variety of names. To botanists it is commonly known as *Luffa fœtida*. We have grown it as Rag Gourd. The name Dish Cloth Gourd can be as well applied to it as to the other. The uses of the fruit are the same as those of *Sua-kwa*.



Sing-kwa.—Luffa acutangula.

III. MISCELLANEOUS VEGETABLES.

Ga-lon-ow, *or Chinese Pea.* (*Pisum sativum.*)

The pea of the Chinese gardens behaves like a little improved or perhaps ancient type of the common pea. It is the same species as ours. It differs chiefly in having somewhat knotty or nstricted pods, as shown in the illustration (p. 198) The pods shell" very hard, and there is a tendency to develop a broad rder or margin along the lower side. The peas are small and e variable in color, and they generally turn dark in cooking. quality, they are sweet and excellent, but they do not possess y superiority over our common varieties.

The seeds which we have obtained from the New York Chinaen are mixed. In color, the peas run from nearly white to rk brown. The brown seeds, however, have given us much rlier pickings than the light ones. In one instance, the seeds ere sorted into three grades, light, medium light, and dark own, and all were planted in sandy soil on the 20th of April. n the 5th of July, the dark-seeded plot gave a good picking, hile the light-seeded, and even the medium plots, produced uch taller plants and very few of the pods had begun to fill he dark and medium-seeded plots produced plants with colored owers,—the standard being rose-purple and the keel blackrple and splashed. The light-colored seeds, on the other hand, ve pure white flowers, larger leaves and broader pods. These cts are interesting in connection with the evolution of the garn pea and its relationship to the red-flowered field-pea.

Tou-kok, or Chinese Bean. (*Dolichos sesquipedalis*).

This is a pole bean with few-seeded pods of great length and hich are eaten after the manner of the pods of string beans. The me species, but commonly a shorter-podded variety, is sold by r seedsmen as French Yard-Long Bean. This bean is native South America, and is widely cultivated in warm countries. requires a long season, but we have little difficulty in securing ods twenty inches long. These pods are very slender, and somehat flattened and ridged, and the beans are often placed two ches apart. The beans are like those of the French Yard-Long, -small and oblong (½ inch or less long), cinnamon-brown, with white black-bordered eye. Mr. Wah Hang tells me that the hinese name of this bean signifies "very long plain October," a ame which is applicable to length of pod and season of ripening. urr,* in speaking of this species, mentions a "variety known as

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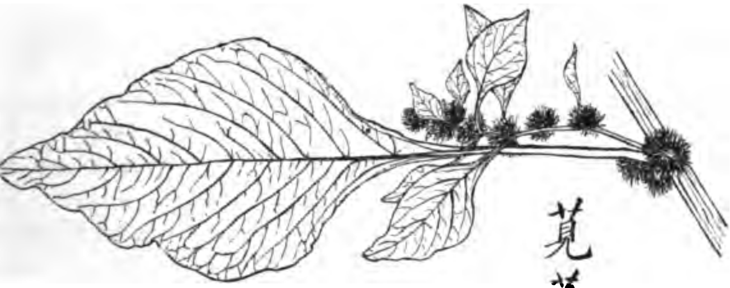
* Garden vegetables, 287 (N. Y., 1866).

Ga-lon-ow, or Chinese Pea.—Pisum sativum.

e Chinese Long-Pod," which "produces pods of much greater ıgth, often measuring nearly three feet." I believe that this an is well worth growing in American gardens, if one enjoys a e vegetable of the string-bean type.

Hon-toi-moi. (*Amarantus Gangeticus*).

This plant is used while young for greens. It is very closely ied to the common Beetweed or Pigweed, a plant which is nilarly used in many parts of this country. The plant is widely ltivated in oriental countries and seems to be much prized. The inaman of whom I procured seed parted with it reluctantly, ying that it was very choice. Yet I am unable to discover any usual merit in the plant for American gardens. In the south, introduced, it might become a weed, but it has not shown that ndency here. Our first sowing was made in 1891, and the ound has been much neglected since. It came up from self-wn seed in 1892, but it has not been seen since.



af and flower-clusters of Hon-toi-moi.—Amarantus Gangeticus.

莧菜米

Yon-soi. (*Coriandrum sativum*).

THIS is coriander, the young leaves of which are relished as a condiment by the Chinese. I am not sure if this Chinese plant is identical with the plant of our gardens. Louriero, a botanist who wrote upon the flora of China over a century ago, mentions the plant, taking it to be e same as the European coriander. DeCandolle*, however, expresses a doubt as to the identity of the two, but Hemsley, in his recent flora of China, regards them as the same. The Yonsoi, as we have grown it, has leaves rather more finely cut than the common coriander, and the flowers are somewhat different in appearance. But in horticultural value the two are not unlike.

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* Prodromus, iv. 250.

SUMMARY.

Various garden vegetables have been introduced into this country by the Chinese, some of which are worthy a place in American gardens.

The best known, and perhaps the most valuable of these new vegetables, is the Pe-Tsai, or so-called Chinese cabbage. This plant bears a loose lettuce-like head of crisp leaves, which may be used in all the fashions in which cabbage is served. This plant requires a cool and moist soil in which to make its best growth. It is essentially an autumn vegetable.

The Chinese mustard is an excellent plant for greens and produces an enormous amount of herbage. Its culture demands the same attention as that advised for Pe-Tsai.

California Peppergrass appears to be a finely cut-leaved form of a mustard long known in old gardens, but not described either in American botanies or gardening books. It is one of the best of all plants for early spring greens. Although the species is cultivated in China and Japan, it does not appear to have been independently introduced from those countries in recent years. It is not known how or when the plant first came into this country.

Other mustard-like plants recently introduced from China are the Pak-Choi, used as greens and for the white thick leaf-stalks; and the Tuberous-Rooted Mustard, grown for its small turnip-like root. These plants possess less merit for American gardens than the foregoing species.

Of the various squash-like plants introduced by the Chinese, the best is probably the Wax Gourd or Zit-kwa. The fruit of this is excellent for conserves. The plant is of easy culture, but requires a long season.

The La-kwa or Momordica has more merit as a curiosity and ornamental vine than as an esculent, for American tastes. It not new to the American seed trade.

The luffas or Dish Cloth Gourds of the gardens are of two ecies, which differ chiefly in the contour of the fruits. The mmoner species in this country has ribless cylindrical fruits, but e one chiefly grown by the Chinese about New York has club-aped ribbed fruits. These fruits are interesting to us chiefly as curiosity and as yielding a sponge-like fiber which is useful for usehold purposes.

The Chinese pea has little to recommend it to American gar-ners.

The Chinese bean or Tou-kok is no doubt a valuable vegetable r late home use.

The remaining Chinese vegetables here discussed—Hon-toi-moi d Yon-soi—have very little value for our gardens.

L. H. BAILEY.

Bulletin 68. **August, 1894.**

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

The Cultivated Poplars;

WITH REMARKS UPON THE PLANTING OF GROUNDS.

By L. H. BAILEY.

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Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.

THE CULTIVATED POPLARS.

I. GENERAL REMARKS.

There has been little attempt in experiment station literature to scuss matters of ornamental gardening. The so-called practical oblems connecting directly with bread-winning have necessarily d properly absorbed the energies of investigators. But the namentation of rural and suburban homes is quite as much thin the province of experiment station work; and it should so be remembered that the growing of plants is itself an indus- which enlists a vast amount of capital, and this nursery busi- ss has received little direct and explicit aid from experiment ation publications. The present essay is undertaken for the uble purpose of explaining certain fundamental principles in ndscape gardening—a subject to which the poplars readily lend emselves—and of unraveling a web of difficulties respecting the ecies and varieties of poplars, into which the nursery catalogues em to have fallen. An investigation of the botanical and horti- ltural features of the poplars has been assiduously prosecuted for wards of two years, and the writer has had the free use of var- us nurseries and plantations in Western New York and the aid botanists in many parts of the country. As a group, the pop- rs possess comparatively small value in landscape planting, but is very fact affords me the opportunity I seek to press home e fallacy of certain common practices amongst planters.

At the outset, I must be allowed to explain that landscape gar- ning is the embellishment of grounds in such fashion that they all possess landscape or nature-like effects. This definition at ce removes from our consideration all the formal effects of wer-beds and sheared trees, which, while useful at times, bear closer relation to landscape gardening than a cup of paint bears the fine art of painting. In other words, a landscape garden— d that should mean every country yard, however small or sim- e—should have in it the elements of a picture. It should appear have one thought or feeling running through it all, and this is a condition which is impossible when trees or bushes or flower-beds are scattered all over the place, for in such case one is attracted by these individual and detached objects and is not particularly impressed with the place as a whole or as a unit. Such a yard is a nursery. An artist would not care to paint such an area. If a yard is to be a picture, it must have a sense of frame-work about it,—certain strong groups of bushes or trees about the borders, and the central area should be a more or less open greensward with very cautious planting. The different parts are then in masses or in bold contrast, and the place has character. At the same time, the partial shutting off of the surrounding areas sets bounds to the place, defines it, and makes it to appear personal, snug and home-like. One should learn that it is not plants which make a place attractive, but the arrangement of plants. In fact, many otherwise attractive places are ruined by a wealth of good plants scattered without purpose over the lawn.

It is but a corollary of this discussion to say that plants which are simply odd or grotesque or unusual should be used with the greatest caution, for they introduce extraneous and jarring effects. They are little in sympathy with a true landscape garden. An artist would not care to paint an evergreen sheared into some grotesque shape. It is too formal and it has no elements of true beauty. It is simply curious, and shows what a man with plenty of time and long pruning shears can accomplish.

This leads me to one of the proper subjects of this paper, the planting of the Lombardy poplar. Fortunately, this tree is less planted in New York than in many western states. Its chief merits to the average planter are the quickness of its growth and the readiness with which it multiplies by cuttings. But in the north it is apt to be a short-lived tree and it suffers from storms, and it has few really useful qualities. It may be used to some advantage in windbreaks for peach orchards and other short-lived plantations, as explained in Bulletin 9 of this station ; but after a few years a screen of Lombardies begins to fail and the habit of suckering from the root adds to its undesirable features. For shade, it has little merit, and for timber none. People like it because it is striking, and this, in an artistic sense, is its gravest fault. It is unlike anything else in our landscape, and does not

into our scenery well. The Lombardy should rarely, if ever, be
en as a single specimen ; and above all, its formality and stiffness
ould not be emphasized by planting it in rows along country roads.
row of Lombardies along a roadside is like a row of exclamation
ints !

But the tree can often be used to good effect as one factor in a
oup of trees, where its spire-like shape, towering above the sur-
inding foliage,
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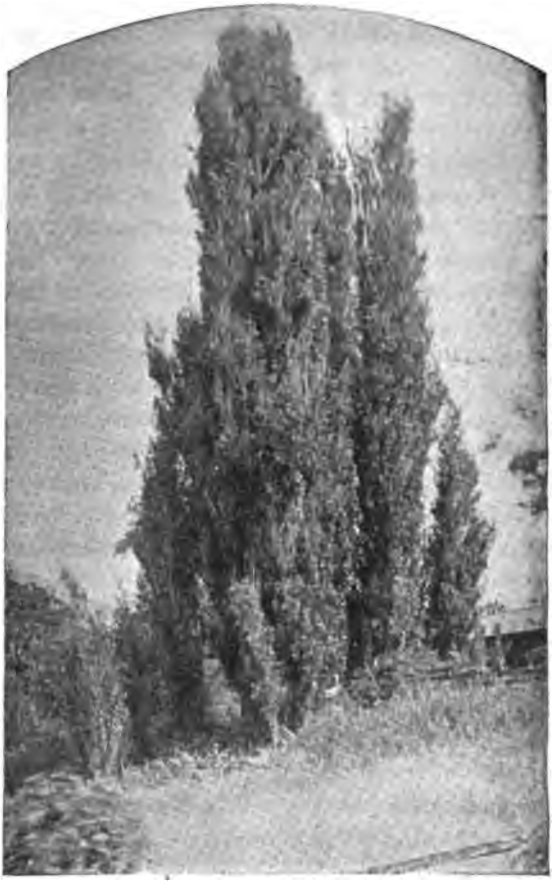

Attractive Group of Lombardy Poplars.

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sees a picturesque clump of Lombardies standing alone, like that shown upon page 207. Here the one original tree has given rise to a varied progeny of sprouts, and the mass has a freeness of outline which can never be obtained in a regularly planted clump of these trees from which the suckers are continually removed. This particular clump is one of the most picturesque objects in a sweeping landscape near Perry City, Schuyler County, N. Y., but its excellence is purely accidental.

Another feature of common ornamental planting which is well illustrated in the use of poplars, is the desire for plants simply because they grow rapidly. A very rapid-growing tree nearly always produces cheap effects. This is well illustrated in the common planting of willows and poplars about summer places on lake shores. Their effect is almost wholly one of cheapness and temporariness. There is little that suggests strength or durability in willows and poplars, and for this reason they should always be used as minor or secondary features in ornamental or home grounds. Where quick results are desired, nothing is better to plant than these trees, but better trees, like maples, oaks, or elms, should be planted with them and the poplars and willows should be removed as fast as the other species begin to afford protection. When the plantation finally assumes its permanent characters, a few of the remaining poplars and willows, judiciously left, may afford very excellent effects ; but no one who has an artist's feeling would be content to construct the frame work of his place of these rapid-growing and soft-wooded trees.

I have said that the legitimate use of poplars in ornamental grounds is the production of minor or secondary effects. As a rule, they are less adapted to isolated planting as specimen trees than to use in composition,—that is, as parts of general groups of trees, where their characters will serve to break the monotony of heavier foliage. The poplars are gay trees, as a rule, especially those, like the aspens, which have a trembling foliage. Their leaves are bright and the tops are thin. A few of them in judicious positions give a place a sprightly air. I especially love the common aspen or *Populus tremuloides* of our woods (Fig. 14). Its light dancing foliage and silver-gray limbs always cheer me, and its autumn color is one of the purest golden-yellows of our landıpes. I like to see a tree of it standing out in front of a group maples or evergreens. Its whole attitude is then one of famil-ity.

The cottonwood is perhaps the best of all our poplars as a single ecimen. It makes a noble tree, spreading its gray branches far d wide. But like the aspen, it is cheerful and restive. One is t moved to lie under it, as he is under a maple or an oak. Its ıves rustle with the lightest movement of air. The ripple of foliage always recalls to my mind the play of wavelets upon a bbly shore. The day is never so dark, but the cottonwood flects a flood of light.

Some of the forms of the black poplar of Europe are especially tisfactory for the production of lively effects in planting. Of ese, I know of none better than the form known to nurserymen *Populus elegans*. It has a most pleasing light and tremulous liage, the effect of which is heightened by a twiggy character of owth and a reddish cast to the leaf-stalks and young shoots. It an elegant tree, and well adapted to planting in front of heavier liage in the most conspicuous portion of the grounds.

Some of the silver or white-leaved poplars produce the most riking contrasts of foliage, especially if set near darker trees. olle's poplar (*Populus Bolleana* of the nurseries) is one of the best of ese trees. Its habit is something like that of the Lombardy. he upper surface of the deeply lobed leaves is dark dull green, hile the under surface is almost snowy white. Such emphatic ees as this should generally be partially obscured, by planting em in amongst other trees so that they appear to mix with the her foliage, or else they should be seen at some distance. Other rieties of the common white poplar or abele are occasionally seful, although most of them sprout badly and may become a uisance. But the planting of these immodest trees is so likely to overdone that I scarcely dare recommend them, although, hen skilfully used, they may be made to produce most excellent fects. If any reader has a particular fondness for trees of this ass (or any others with woolly-white foliage) and if he has only ordinary farm-yard to ornament, let him reduce his desires to single tree, and then if that tree is planted well on the inside of group of other trees, no harm can result!

There are various weeping and grotesque horticultural varieties of the poplars, as of other trees. Concerning the use of these, I need only say that they are curiosities and that they should not be given prominent positions directly in front of the house. I think that no one will care to dispute me if I say that a person who fills his front yard with such specimens, has little appreciation of natural objects. A few grotesque specimens in positions of secondary importance may be desirable, as in a side or back yard, but one will find that the more he cultivates a love of natural scenery the less he cares for mere monstrosities.

I may seem to have placed myself in the position of writing a bulletin upon a group of trees which, upon the whole, I should be quite as willing to discourage as to augment; but my object has been rather more, as I intimated at the outset, to point out certain common defects in habits of thinking about ornamental trees, and to discourage the use of trees simply because they are odd, quick-growing and cheap. I wish that there were fewer Lombardy poplars in many parts of the country, fewer of the ugly white or silver poplars, and more of the American and European aspens, of the large-toothed aspen, of the cottonwood, and the Russian Certinensis poplar. Many of the species are excellent for covering sand-hills—for which the white poplar is well suited—or rough or waste places, and they are capable of adding much light and cheer to a yard. But planters are too prone to use certain ones over freely.

Poplars are often disagreeable upon the lawn because of the abundance of down or wool which they give to every breeze in May and June, when the seed-pods burst. There is really little occasion for this annoyance, however. The poplars are diœcious, —that is, the male and female flowers are upon different trees (although both sexes are rarely upon the same trees in the cottonwood). Nurserymen, therefore, should grow only the male specimens. The cuttings from a male tree—or one producing no cottony seeds—will give progeny of the same character. Of the Lombardy, there is only the male sex in the country, the female never having been introduced, or at least not distributed, so far as I know; while the weeping willow is represented only by the female plant. Some of the species and varieties are worth planting for the catkins which are produced so freely in early spring. The European aspen (*Populus Tremula*) is particularly desirable in this respect (Fig. 13); and this species also has a most interesting habit and foliage.

It should be said, in passing, that most of the poplars are hardy trees and thrive in a great variety of trying situations. This, together with the ease of propagation and their cheapness, combined with free and rapid growth, makes them the best of trees for nurse plantations,—that is, for temporary shelter for other trees and bushes. In this respect the common aspen poplar is one of the most valuable of all trees in the reforestation of American lands. It springs up quickly in clearings, and during its comparatively short life holds the soil and protects other vegetation and finally contributes its own substance to the maintenance of the stronger forests. In this manner it has exerted a most powerful effect upon the configuration of our forest areas and upon the fertility of the land from remote time. The same qualities make it valuable, in many instances, in extensive ornamental plantings.

The recent introduction of Russian poplars has added considerable confusion to nursery lists, and it was this fact which first led me to take up this inquiry. The chief merit of the Russian trees is for planting in the northwestern prairie states, but all of them are worth attention for exposed localities in this state, as well as for ornamental planting. I am convinced that the so-called *Populus Certinensis* (properly *P. laurifolia*) is one of the very best trees to plant where quick results are wanted and where some feeling of strength and durability is also desired. The best discussion of these Russian poplars which I know is contained in Bulletin No. 9 of the Minnesota Experiment Station by Professor S. B. Green, published in 1889. The following is a more recent sketch of these trees by the same author, prepared for this occasion :

"*Russian Poplars in the Northwest.*—In the arboretum of the Minnesota Experiment Station are 12 kinds of Russian poplars that were received from the Iowa Agricultural College. Most of them have been grown in our collection for seven years, and some of them have been tried for a much longer period in other parts of Minnesota, in Iowa and the Dakotas, but not long enough anywhere in this country to warrant final conclusions. Those who live in locations naturally in timber can hardly understand the importance of the genus, to which these trees belong, to the pioneers on the wind swept prairies. The ease with which many of them are increased, their rapidity of growth, great hardiness against extremes of heat and cold, excessive moisture, and prolonged drouth, make them widely sought as pioneer trees in most severe locations, for the formation of wind-breaks and for shade from the scorching sun.

"I would not be understood as recommending the general planting of poplars where our finer deciduous trees readily succeed, but for a strong effect in the shortest time in severe locations they have no rival except the large growing willows, which may generally be used with them to advantage. Among the collection of poplars commonly referred to as of Russian origin, are trees having a great variety in growth and foliage, so that by the judicious use of them alone one can secure very good effects in landscape planting. They are not, however, and never have been, represented as new species, but as hardier forms of species already introduced into this country, and in the following notes I have grouped the kinds under the several heads where they evidently belong, using their nursery or horticultural names. Aside from the few exceptions noted, they are all easily increased from hard wood cuttings made in the fall or spring.

"ANGULATA CLASS—*Young growth plainly marked with ridges or angles.*

Dudley's Populus [properly *P. balsamifera*, var. *viminalis*]. Growth only moderate; when young rather upright in habit, but somewhat pendulous when old. Our older specimens have been badly injured by leaf rust in dry summers, and on this account I have ceased propagating it. The leaves are broadly lanceolate, very wavy on the edges and the young branches very angular.

"*P. betulifolia* is probably the same species as *P. nigra* of the eastern nurseries. It makes a tree that is rather open in habit, inclining to a straight trunk with branches coming out at nearly right angles. The foliage remains bright and fresh even in dry sod land in severe seasons. It is not especially valuable for timber but is interesting and useful for contrasting with other trees; leaves very thick, very large and broadly deltoid, much larger and broader than leaves of the cottonwood under like conditions.

"*Wobsky Poplar.* One of the most distinct of its class; of rapid growth and open regular habit. As a timber tree it is upright and valuable, but it seems to be more susceptible to the work of the poplar borer than other kinds and it occasionally loses its foliage in dry places. On account of these weaknesses it will not be largely planted in this section, but occasional trees may often be used to give variety. The leaves are large, ovate heart-shaped, stiff and very flat, of a shiny blue-green color on the upper and a light green on the lower side. Buds large and sticky. The young growth is only slightly angular.

"*P. Certinensis* [*P. laurifolia* of botanists] was introduced into this country and disseminated by Arnold Arboretum. It is perhaps the best of the collection for general prairie and ornamental planting in this section; perfectly hardy even in the severest exposures and rarely, if ever, affected with leaf rust which so often checks the growth of the cottonwood. Its timber makes very good siding for buildings and floors, and answers many of the purposes for which pine is generally used. It does not warp or crack like our native cottonwood. It is rather upright in form, with thick leathery leaves and of very rapid growth. It does not grow quite as fast as the native cottonwood nor resist the attacks of the leaf beetle so successfully, but it is a much longer-lived tree and stands close planting very much better. It is grown readily from cuttings, which in our forest plantation made a growth of a trifle aver 12 feet in three years from half-inch cuttings planted eight inches apart in rows eight feet asunder. The leaves are thick and leathery with a wavy edge. The new wood is strongly angular. [The form of leaf is shown in Figs. 7 and 8.]

"The *Populus Petrovski* so closely resembles *P. Certinensis* that I think them one and the same thing. Professor Budd obtaided this in Russia and thinks it different from the latter. If this is true it does not show its characteristics until older than any specimen we have.

"The poplar known as *P. pyramidalis* var. *fastigiata* is evidently the Russian form of the Lombardy, if not the same thing. It has been introduced in the hope that it would prove hardier and longer lived than the common form, but in our experience of some seven years, young trees of either form have never been injured in this vicinity. It may, however, prove to be a longer lived tree than the common Lombardy, which is well known to be quite hardy, even in somewhat severe locations, when young, but to be very short lived on the dry prairies of the Northwest. It is, however, interesting to know that while the common Lombardy poplar is an almost worthless tree in most parts of Minnesota, yet near Duluth and along Lake Superior it is quite a success.

"BALSAMIFERA CLASS.—*With large sticky buds and young growths free from ridges or angles.*

"*Populus balsamifera* of Asia, as we have it, is probably the type of which *P. laurifolia* and *P. Sibirica var. pyramidalis* of horticulturists are but variations. The lamented Chas. Gibb said he saw in the botanical gardens at Kazan a specimen of this two feet in diameter and 50 feet high, and although it resembled *P. Sibirica* when young, it is quite different from it in form when old. Either of the next two kinds are preferable to it for planting, as the leaves of this have an unpleasant way of curling together.

"*P. Sibirica* var. *pyramidalis* [a form of *P. balsamifera*, var. *intermedia* of botanists], makes a fair growth and is desirable for ornamental planting. I think the foliage will endure more hardship than the *P. balsamifera*, to which it is similar in form.

"*P. laurifolia* [of horticulturists, but *P. balsamifera*, var. *intermedia* of botanists] is the best of this class. It is little slower growth than the *P. Certinensis* but like it healthy, vigorous and a good timber tree, and much superior to the cottonwood for lumber or fuel. Its thick leaves withstand the hottest, dryest air of the West, either standing alone or in shelter belts. The leaves are thick and leathery, oval in form, a smooth clear white on the under side, and a bright clear green on the upper; generally flat, but sometimes a little folded.

"WHITE POPLAR CLASS.—The typical Russian form of this is rather more upright than the common white poplar and does not sprout so much. This latter quality will be considered desirable by growers of occasional specimens. On the other hand, it is not so easily propagated as the common form and is perhaps, no hardier, so that it will not supplant it for forest plantations where the beautiful white, fine-grained wood of this species is desired, and where the habit of sprouting from the roots is no drawback.

"*P. alba* var. *Bolleana* is very different from the common white poplar, which it resembles in foliage and bark, but its leaves are nearly as deeply lobed as those of the common silver maple; on the upper side they are of a rich dark green color, while on the lower side they have a very heavy coat of white down. Its growth when young is nearly as upright as the Lombardy poplar with a tendency to a globular formed head when old. It is, however, a long lived tree even in severely dry sections in the West, where the Lombardy poplar is worthless. It is of rather moderate or slow growth. I find it much more difficult to propagate than most other poplars, but have had fairly good success with cuttings taken off in the fall, and well callused before planting

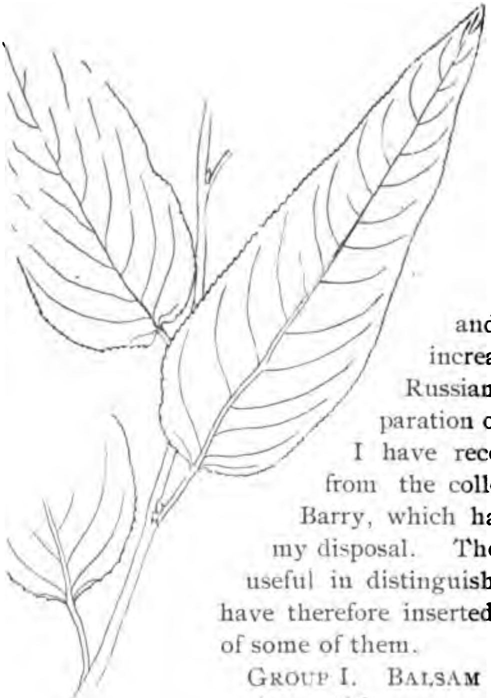
1. **WINTER TWIGS OF POPLARS.**—a, b, c, d, *forms of Populus grandidentata;* e, *P. angustifolia;* f, *P. nigra, var. elegans;* g, *P. balsamifera, var. latifolia* (*Nolestii*)*;* h, *P. nigra* (*Eugenie*)*;* i, *P. monilifera;* j, *P. laurifolia* (*Certinensis*)*;* k, *P. balsamifera, var. viminalis;* l, *P. nigra* (*form known as Canescens*)*;* m, *P. alba, var. canescens;* n, *P. alba, var. nivea;* o, *P. alba.*

in the spring, in the same manner as practiced with grape cuttings in the West. It grafts readily on several of our common poplars and on strong growing kinds its growth is considerably increased.

"*P. alba* var. *argentea* closely resembles the species but has heavier down on the underside, and is rather more spreading in habit, and is more easily propagated from cuttings."

II. THE CULTIVATED SPECIES OF POPLARS.

The following catalogue attempts to refer the nursery and horticultural names of poplars to their proper botanical species, and it includes various notes upon the horticultural values of the different types. The genus appears to be much confused amongst nurserymen, and the perplexity has been increased by the arrival of the Russian varieties. In the preparation of this monographic list, I have received the greatest aid from the collection of Ellwanger & Barry, which has been freely placed at my disposal. The winter twigs are often useful in distinguishing the species, and I have therefore inserted a photograph (Fig. 1) of some of them.

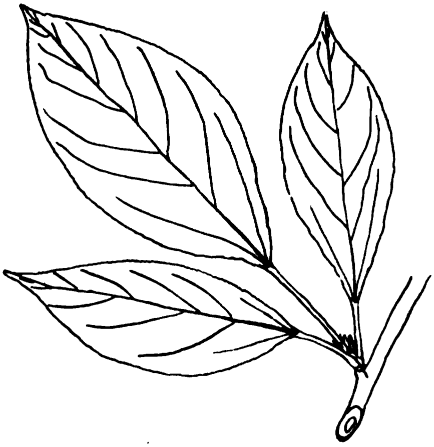


2. *Populus angustifolia.* (*½ nat. size.*)

GROUP I. BALSAM POPLARS, *or those with resinous-sticky more or less elongated buds.*

1. **Populus angustifolia** (James, Long's Exped. i.497). YELLOW or BLACK POPLAR of the west. Fig. 2. A pyramidal small tree with ovate-lanceolate willow-like leaves and cylindrical twigs, native from South Dakota west and south. It is sparingly cultivated. It is a tree of good habit and soft clear green foliage, and is worth attention in the composition of groups. May be confounded with *Populus balsamifera*, var. *viminalis*, which see. The slender, cylindrical winter twigs with small buds (e, fig. 1) are very different from the heavier and angled shoots, with coarse buds, of the other (k, fig. 1).

2. **Populus balsamifera** (Linnæus, Sp. Pl. 1034 (1753). BALSAM POPLAR, TACMAHAC. Fig. 3. A tall upright tree, with a narrow straight top, growing in woods and along streams in the Northernmost States, and also in Northern Europe and Asia. Leaves thick and firm, erect, whitened beneath, usually smaller than in most other poplars of this Group: in shape ovate-lanceolate or oval, tapering towards the top and sometimes at the base, finely and obtusely toothed. Young branches nearly or quite cylindrical.



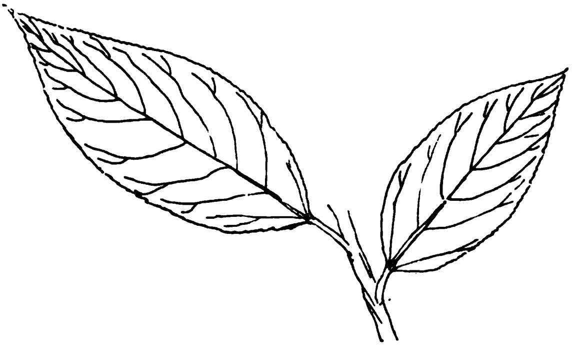
3. Populus balsamifera (16 Voronesh.) (½ *nat. size.*)

The native form is occasionally seen about farm buildings and roadsides, where it makes a durable and pleasant tree; but it is most too stiff for the pleasantest effects and too narrow for the best shade. The dull whiteness of the under side of the leaves affords a pleasant variety and contrast in its foliage, and the fragrance of the resinous buds in spring is pleasant to most persons. It is a desirable tree for occasional planting, but, like the Lombardy, it generally appears to best advantage when placed amongst other trees. It is a hardier tree than the Lombardy, and does not run quickly to such extravagant heights. In cultivation from Russian sources, it is known as Nos. 16 and 26 Voronesh and 32 Riga. Fig. 3 shows ordinary foliage (16 Voronesh) about half size.

The balsam poplar is probably the most variable of poplars.

In cultivation in this country it is represented by no less than three well marked botanical varieties, differing from the species and from each other in the habit of growth, shape and color of leaves and character of twigs.

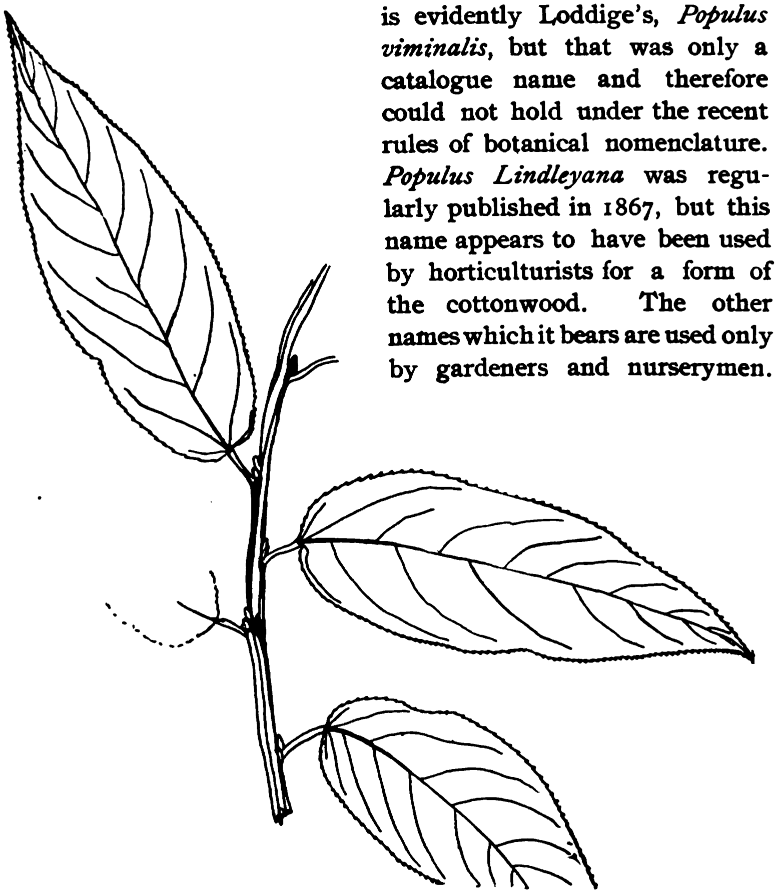
P. balsamifera variety **intermedia** (Loudon, Encyc. of Trees and Shrubs, 830 (1842). *P. laurifolia* of American horticulturists, not of botanists. *P. Sibirica pyramidalis*, of horticulturists). Fig. 4. A comparatively slow growing tree of close upright habit, from Northern Europe, where it is used as a street tree. The leaves are very thick and hard, finely serrate, oval in outline, and prominently whitened beneath, and they are commonly rather small for this group. Twigs hard and cylindrical. It is considered to be a valuable tree for hot and dry interior climates; and it also has distinct merit for ornamental planting. It eventually becomes a large tree. The *Populus laurifolia* and *P. Sibirica pyramidalis* of American nurserymen are, so far as I can determine, only minor variations of one varietal type. All these trees are amongst the recent introductions of Russian poplars.



4. *Populus balsamifera* variety *intermedia*. ⅔ *nat. size.*

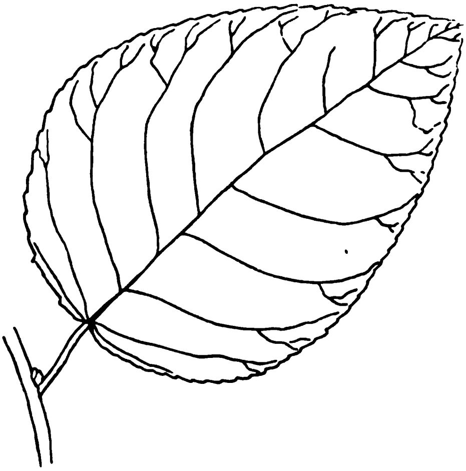
P. balsamifera var. **viminalis**, (Loudon, Encyc. 830, t. 1510. *P. viminalis*, Lodd. Cat. (1836). *P. Lindleyana*, Booth, Rev. Hort. 1867, 380. *P. salicifolia*, *P. crispa*, *P. Dudleyi*, and *P. pyramidalis suaveolens* of horticulturists. Also sometimes called *P. laurifolia*). Fig. 5. A tree of only moderate and rather slender growth, with a partial weeping habit when old; native to northern Europe. It is at once distinguished from other forms of *Populus balsamifera* by its sharply angled twigs (k, fig. 1), and broad-lanceolate willow-like leaves which are finely serrate and often crinkled-margined.

I am inclined to regard this as a distinct species from the balsam poplar. If it should be elevated to specific rank, it would be difficult to determine a correct name for it. Its first specific name is evidently Loddige's, *Populus viminalis*, but that was only a catalogue name and therefore could not hold under the recent rules of botanical nomenclature. *Populus Lindleyana* was regularly published in 1867, but this name appears to have been used by horticulturists for a form of the cottonwood. The other names which it bears are used only by gardeners and nurserymen.



4. *Populus balsamifera* var. *viminalis.* (*½ nat. size.*)

But however much doubt may attach to the botanical position of this small tree, it is valuable to planters if a tree of willow-like aspect but with more pronounced color effects and greater size and durability is desired. It is very like the native *Populus angustifolia*, which it represents in Europe, but is readily distinguished by its angled or furrowed stems, and less tapering and crisped leaves which are conspicuously finely reticulated and whitened beneath. The color of its foliage is a grayish green, and in this respect it affords a contrast to the native species. The native seems to be rather the better tree of the two, although the *viminalis* has a more striking appearance.



6. *Populus balsamifera* var. *latifolia*. (½ *nat. size.*)

P. balsamifera, var. **latifolia** (Loudon, Encyc. 830. *P. Nolestii* and *P. Wobsky* of horticulturists). Fig. 6.—This variety includes Asiatic forms with ovate or cordate-ovate rather blunt pointed leaves, cylindrical twigs (or slightly ridged on strong shoots) (g, fig. 1) and the general habit of the balsam poplar. The leaves are usually large and thick, shining green above and dull white beneath, in shape and texture somewhat like the next species (*P. candicans*). The Nolestii poplar is now sold by Eastern nurserymen as an ornamental tree. Its strong habit and dark foliage adapt it admirably to planting near the rear borders of grounds. The Wobsky poplar is one of the recent Russian introductions, with somewhat the habit of a cherry tree, and is much prized in the northwest. The Rasumovskoe poplar appears to be of the same type.

3. **Populus candicans** (Aiton, Hort. Kew. iii. 406. *P. balsamifera*, var. *candicans*, Gray, Manual, 2nd ed. 419. *P. Ontariensis* and *P. macrophylla* of European horticulturists). BALM OF GILEAD. Fig. on title page.—A strong-growing spreading native tree, frequently planted, and esteemed for its vigor and hardiness and the resinous fragrance of its large buds in spring-time. The leaves are broad and heart-shaped, green above and veiny and rusty-white beneath, and the leaf-stalk is usually hairy and somewhat

flattened. It is very different from the balsam poplar in method of growth, as it has none of the pyramidal or spire-like tendency of that species, but usually makes a broad and irregularly spreading top. While the tree is common in cultivation, it is rare wild. In the early days, however, it was found in very large trees in Michigan and other western states, and was used for sawing timber; and isolated natural groves of it are still occasionally seen.* The balm of gilead makes a good street tree, and is perhaps the best of the poplars for shade. Well grown trees have the darkest and richest foliage of any common poplar, and this character makes the tree valuable in heavy groups about the borders of a place. The top is liable to become open and broken with age, however, and the tree often sprouts profusely. It is not well adapted to smoky and dusty locations, as it soon becomes grimmy. It was used to good purpose in the lagoon borders of the World's Fair, where its exuberant growth and stiff heavy leaves gave a massive effect. The illustration upon the title-page shows a spray of the balm of gilead, one-third natural size.

4. **Populus Simonii** (Carrière, Rev. Hort. 1867, 360).—A strong strict tree from China, whence it was introduced into France about 1861 by M. E. Simon. It is now very sparingly planted in this country, but its merits are scarcely known. In foliage it is much like the next species (*P. laurifolia*). Its leaves differ from those of the balm of gilead in having a rounded or tapering base and much finer teeth, but otherwise they are much alike. The shoots are reddish brown and spotted, and deeply grooved. Professor Craig, of the Central Experimental Farm, Ottawa, Ontario, who has had considerable experience with the tree, writes as follows concerning it:

"The tree in nursery and on the lawn is a very strong grower, with large ovate leaves, having the characteristic five-sided shoots of these Russian poplars. It grows very rapidly, making a growth of from six to ten feet per annum. I have not known it to winter kill either here or in Manitoba. It can hardly be termed strikingly ornamental, but is useful for planting where windbreaks are desired quickly. Like the Carolina poplar, it has a strong upright habit of growth."

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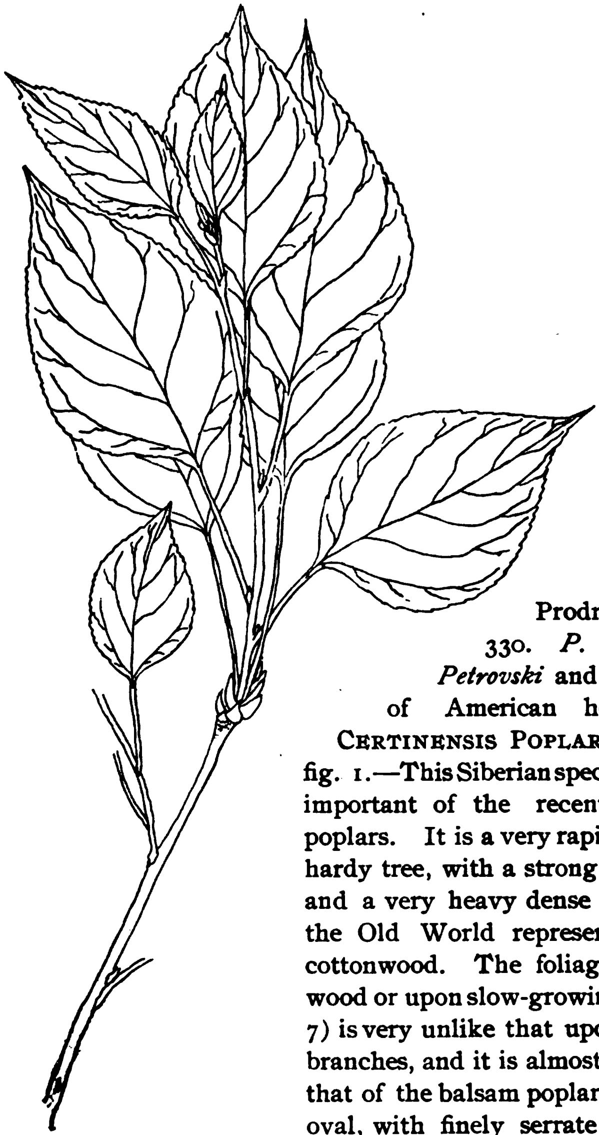
* Botanical Gazette, v. 91.

5. **Populus laurifolia** (Ledebour Icones Plantarum Nov. Ross. v. 23, t. 479 (1834). *P. balsamifera*, var. *laurifolia*, Wesmael, D. C. Prodr. xvi. part ii. 330. *P. Certinensis*, *P. Petrovski* and *P. Bereolensis* of American horticulturists).



7. Populus laurifolia (or P. Certinensis). Slow-growing shoot. (2/3 nat. size.)

CERTINENSIS POPLAR, Figs. 7, 8; j. fig. 1.—This Siberian species is the most important of the recently introduced poplars. It is a very rapid-growing and hardy tree, with a strong central leader, and a very heavy dense foliage. It is the Old World representative of our cottonwood. The foliage upon the old wood or upon slow-growing shoots (Fig. 7) is very unlike that upon the vigorous branches, and it is almost identical with that of the balsam poplar, being broadly oval, with finely serrate margins, and whitish beneath. The twigs, also, are cylindrical. But the strong shoots are strongly angled or grooved and the foliage is much like that of the native cottonwood but darker; and the growth is more close and erect. The sketch in Fig. 8 distinguishes the leaves perfectly, however:

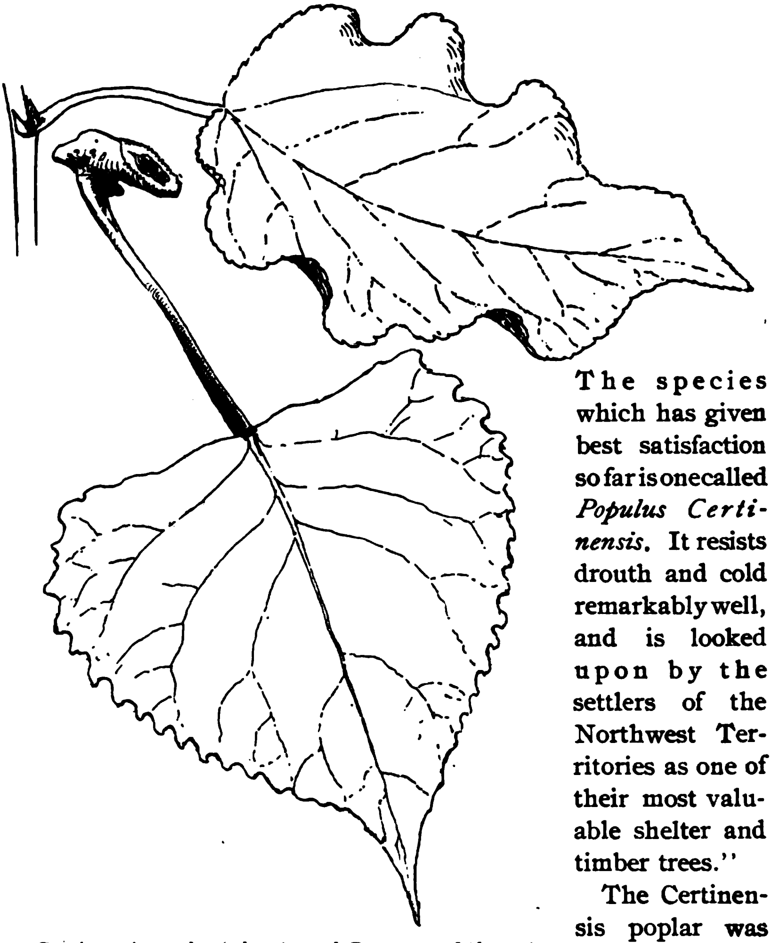
P. laurifolia or Certinensis (upper leaf). Leaves broad-ovate in outline, with a rounded or tapering base and rather short point at the apex; the margin rather closely toothed, wavy; leaf-stalk comparatively short, only moderately flattened, glandless at the top; stipules present and conspicuous. Bud long. Shoots slightly hairy.

P. monilifera or Cottonwood (lower leaf). Leaves triangular-ovate in outline, with a straight or truncate base and a long point at the apex; margin coarsely scallop-toothed, plane; leaf-stalk long, much flattened beneath the blade of the leaf, and commonly bearing two or three gland-like bodies at its top; stipules absent or minute (falling early). Bud shorter. Shoots glabrous.

I imagine that the similarity of the Certinensis poplar and cottonwood has been the means of confusing them, for I have poplars under the names of *P. laurifolia* and Riga No. 40, which are cottonwoods. Whether these were really introduced from Russia after having first been introduced there from America, or whether the confusion is a mixing in our own plantations, I am unable to say. The Certinensis poplar is a more rugged tree than the cottonwood, with healthier foliage in the presence of leaf-rust, and its wood is said to be valuable. It is now much planted in the Northwest, and deserves to be more widely distributed.

Its effect in the landscape is considerably unlike that of the cottonwood. Its leaves out stand more horizontally, while those of the cottonwood hang loosely and often vertically and therefore give the tree top a heavier look. The terminal spray of the two is particularly distinguishable in this regard. The leaves of Certinensis upon the strong erect shoots stand almost squarely at right angles with the shoot, and, at some distance, therefore present only their ruffled edges to the eye, producing a most unique and picturesqne effect. But on the whole, at least for the present, I should consider the cottonwood the better tree for ornamental planting in this state.

Professor Craig, of Ottawa, writes of the species: "I have been sending out cuttings of these so-called Russian poplars to Manitoba and the Northwest Territories for the past four years. The species which has given best satisfaction so far is one called *Populus Certinensis*. It resists drouth and cold remarkably well, and is looked upon by the settlers of the Northwest Territories as one of their most valuable shelter and timber trees."

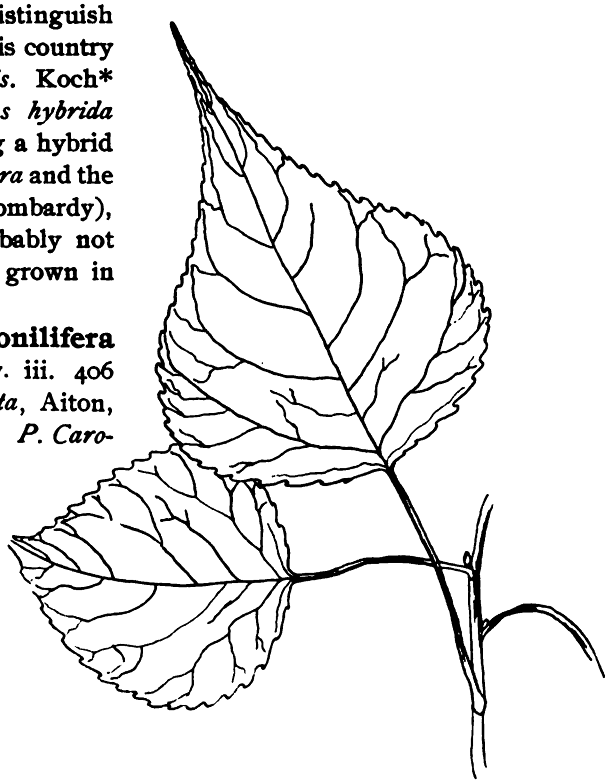


8. *Certinensis poplar* (*above*), *and Cottonwood* (*below*). (*½ nat. size.*)

The Certinensis poplar was used in the lagoon plantations at the World's Fair, but because of its rapid growth in the direction of its leader, it made a less picturesque small tree than either the cottonwood or balm of gilead, which were similarly planted.

The name *laurifolia*, or "laurel-leaved," is generally applied in this country to another plant,—*Populus balsamifera*, var. *intermedia*. The name originated with the Russian botanist Ledebour, and he published a good illustration of the tree he had in mind and it is an admirable portrait of the large and crinkly leaves of the tree which in this country goes under the name of *Populus Certinensis*,—a name which, so far as I can learn, is simply a garden or nursery name. No. 39 Riga, as I have it, is the same. Neither am I able to distinguish the tree grown in this country as *Populus Bereolensis*. Koch* mentions a *Populus hybrida Berolinensis* as being a hybrid between *P. balsamifera* and the Italian poplar (or Lombardy), but his tree is probably not the same as the one grown in this country.

6. **Populus monilifera** (Aiton, Hort. Kew. iii. 406 (1789). *P. angulata*, Aiton, Hort. Kew. iii. 407. *P. Carolinensis*, Moench, Verzeichniss Weissenstein, 81 (1785: Catalogue name). *P. glandulosa*, Moench, Methodus, 339 (1794). *P. Canadensis*, Michx. f. Hist. Arb. Am. iii. 302, t. 12. *P. Carolina* of nurserymen).



9. *Populus monilifera, unusual form.* (*½ nat. size.*)

COTTONWOOD, CAROLINA and CANADIAN POPLAR. Fig. 8, 9; i, fig. 1. A strong growing handsome tree of large size, ranging from western New England to Florida and the Rocky Mountains. Its leaf characters are sufficiently outlined above (under *P. laurifolia*), but it is variable in shape and color of leaves. Some of the forms are fairly distinct in foliage and aspect, and they appear to be associated with particular horticultural names, in the nurseries. Fig. 9 shows a form with very long-pointed and round-based leaves; but it usually bears, also, the typical triangular foliage. Some of the most ornamental specimens of cottonwood are those which have reddish leaf-stalks and midribs.

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* Dendrologie. ii. iA, 497.

Taking all things into consideration, the cottonwood is probably the best of the poplars for general ornamental planting. It grows rapidly and in almost every soil, and yet it possesses an air of strength and durability which most of the poplars lack. Its foliage is always bright and glossy, and the constant movement of the broad rich green leaves gives it an air of cheeriness which few trees possess. The tree has been much used upon the western prairies and in western towns, much too abundantly for good landscape effects. The rapid growth of the tree gives a feeling of luxuriance to plantations, even when most other trees appear to be weak or starved. The cottonwood thrives best upon rather low lands, and yet it is generally an admirable tree upon high and dry areas.

The so-called Carolina poplar is only a very luxuriant cultivated form of the cottonwood. As sold by the New York nurserymen it does not differ otherwise from the wild *Populus monilifera* of our woods and creek borders.

There is a golden-leaved form of the cottonwood known as variety *Van Geertii* or var. *aurea*. It is one of the best of yellow-leaved trees, and generally holds its color throughout the season. Like all trees of this unusual character, it should be used cautiously, and the best effects are obtained when it is planted against a group of trees so as to appear as if naturally projecting from the other foliage.

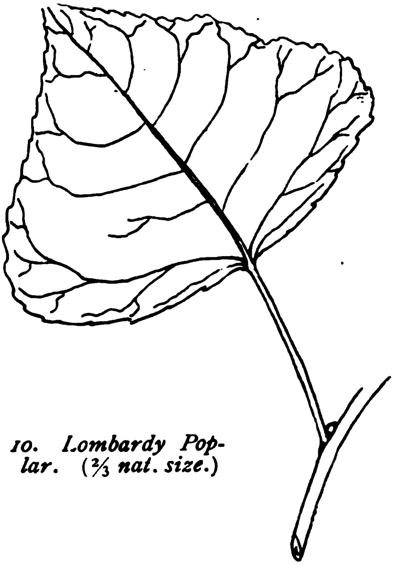
7. **Populus nigra** (Linn. Sp. Pl. 1034 (1753). *P. Hudsonica*, Michx. f. Hist. Arb. Amer. iii. t. 10. *P. betulifolia*, Pursh, Fl. Amer. Sept. ii. 619. *P. Eugenie* of nurserymen). BLACK POPLAR. h and l, fig. 1. A European tree of medium to large size, with leaves somewhat resembling those of the cottonwood, but

generally smaller and much less deeply toothed, shorter in proportion to their width and often with a tapering or rounded base. The tree usually has a pyramidal habit of growth and a dark cast to the foliage. The leaf-stalk is flattened, so that the foliage moves freely in the wind. It is a less lustrous tree than the cottonwood and grows more slowly. Specimens were found escaped along the Hudson by Michaux, who thought it an American species and published it early in the century as *Populus Hudsonica*. Pursh in 1814 published it again as the "birch-leaved poplar," *Populus betulifolia*, from trees found upon Lake Ontario. Although is was found half wild in New York about a century ago, it does not seem to have increased itself in America, for it is rarely seen, even in cultivated ground. The tree known in the West as *Populus betulifolia* is only a robust form of the European *P. nigra*.

The black poplar runs into many perplexing forms. The best which I know is var. **elegans** (*Populus elegans* of nurserymen. f, fig. 1). It is a tree of pronounced strict or pyramidal habit, but considerably broader than the Lombardy. The foliage is small and light colored and very versatile in a breeze, with a handsome reddish tint to the leaf-stalks and young shoots. It is worth growing in every well kept place, especially if placed against a planting of heavier foliage. *Populus canescens* of some American nurserymen is very like this, although it has less color and brightness.

P. nigra, var. **Italica** (Du Roi, Harbkesche Baumz. ii. 141 (1772). Var. *pyramidalis*, Spach, Ann. Sci. Nat. 2nd ser. xv. 31 (1841). *P. Italica*, Moench, Verzeichness Weissenstein, 79 (1785). *P. dilatata*, Aiton, Hort. Kew. iii. 406 (1789). *P. fastigiata*, Desf. Hist. Arb. ii. 265 (1809). *P. pyramidalis*, Rozier, Dict. d'Agric. vii. 619. *P. pyramidata*, *P. Pannonica*, *P. Polonica* of horticulturists). LOMBARDY OR ITALIAN POPLAR. This tree is too familiar to need description. It differs from the typical black poplar (*P. nigra*) in its tall narrow growth, glabrous young shoots, a confirmed habit of suckering from the root and generally a more tapering base to the leaves. It is one of the characteristic trees of parts of Italy, and it is from one of the Italian provinces, Lombardy, that its common name is derived. The tree is probably native in Asia, however.

The Lombardy poplar was much prized in this country a hundred years ago. John Kenrick established a commercial nursery of ornamental trees in Newton, Massachussetts, in 1797, and two acres were "devoted to the cultivation of the Lombary poplar, which was about the only ornamental tree for which there was any demand in those days."* It is probable that very few, if any, of the trees sold by Kenrick are still living, even in localities where the climate is not severe; and this is evidence that the tree is short lived—a fact which all careful observers must have noticed.



10. Lombardy Poplar. (⅔ *nat. size.*)

A hardy type of the Lombardy is grown in the Northwest. Professor Budd gives the following account of it.†

"In the summer of 1882 Mr. Gibb and the writer were surprised to find the Lombardy poplar in perfect health in central Russia, where our American black locust, honey locust and other trees killed down each winter as does the common peach in north Iowa. Our surprise came from the fact that Loudon inclined to the belief that *Populus dilatata* [one name for the Lombardy Poplar] was native to the valley of the Po in Lombardy, from whence it came to England and America. But Russian botanists soon assured us that its home was in the east and that its hardiness varied like other species, and hence depended on the region from whence it was obtained. Under the name of *Populus dilatata* we imported the hardy kind from Voronesh, in central Russia. As this is 300 miles north of the sea of Azoff, from whence came the Russian Mennonites of Minnesota, I suspect that our importation is hardier than the one seen around St. Paul. We call it the Russian Lombardy. It is a much nobler tree than the variety from the Po valley, as its top is not so thin and spiry, and its foliage is thicker and darker. We have not talked about this poplar for the reason that its timber has no relative value. Yet it fills a place in landscape gardening not taken by any other tree.''

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*Garden and Forest, i. 302.

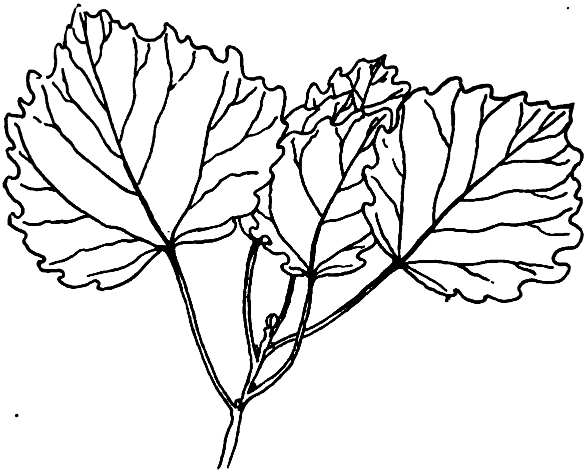
†Rural Life, Aug. 31, 1893, p. 12.

The various merits of the Lombardy poplar—which is the most familiar tree of the genus—have been already discussed. It has been planted too freely, but it is gradually dying out in the east, and time will no doubt eliminate its offensiveness in the landscape. There is said to be a form of the Lombardy with variegated leaves, but I hope that it will not find its way into this country. A tree which is already over-bold would be impertinent with a painted foliage. '' Planted as it was a hundred, or even fifty years ago, in all possible situations, without regard to its surroundings or to the positions in which it was placed, it did more, perhaps,'' says *Garden and Forest*, ''than any tree which has ever been planted, especially in some parts of Europe, to disfigure the landscape. There is no tree, however, which can take its place, or which can so quickly send up a tall, slender shaft to break a low or monotonous sky line. It became an unpleasant feature in the landscape only when it was used without judgment and without discretion.''

GROUP II. ASPENS and WHITE POPLARS, *with short non-glutinous often pubescent buds.*

8. **Populus Tremula** (Linnæus, Sp. Pl. 1034). EUROPEAN ASPEN. Figs. 11, 13.—An open-headed, light-leaved tree, common throughout Europe, and occasionally cultivated in this country, especially in its weeping form. Leaves small and thin round-oval, more or less whitened beneath, especially when young, bordered with deep and rounded incurved teeth. Leaf buds small. The leaf-stalks are long and slender and flattened, giving a restless motion to the foliage.

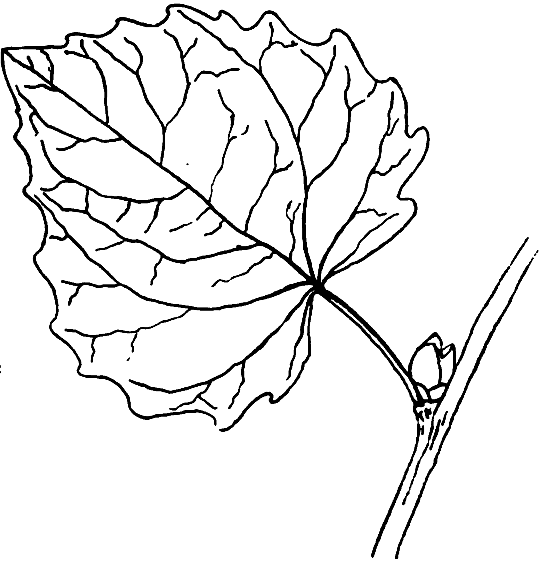
The weeping form of the European aspen is perhaps the best weeping tree amongst the poplars. The spray is light, airy, and fountain-like, quite unlike the more common weeping forms of our native *Populus grandidentata*, which present a stiff weeping aspect, a combination which is rarely pleasing. The lightness



11. Populus Tremula (⅔ *nat. size*).

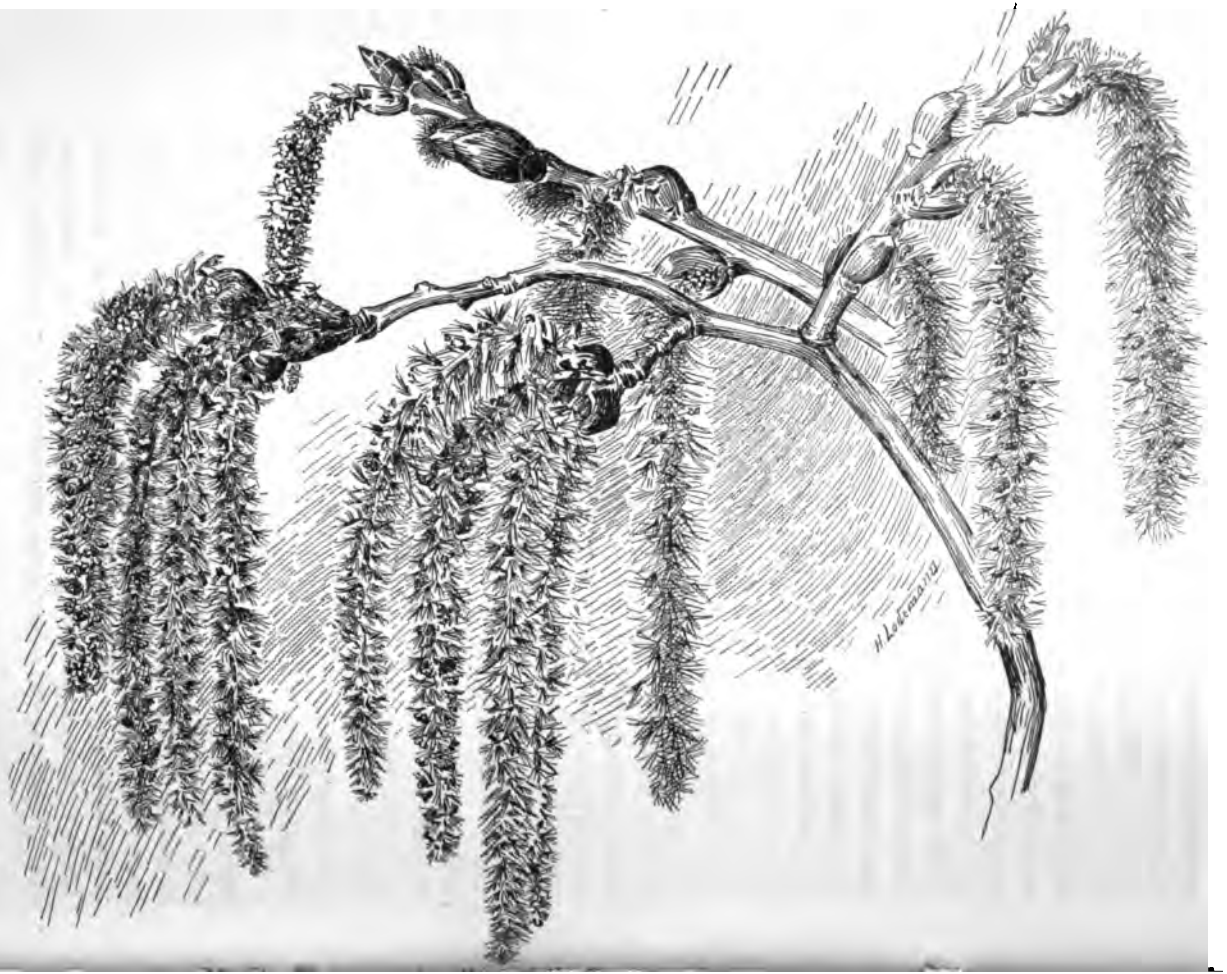
of the foliage of the European aspen has been remarked by writers from the earliest times. Gerarde, in 1597, remarks that the tree "may also be called Tremble, after the French name, considering it is the matter whereof womens tongues were made, (as the Poets and some others report) which seldome cease wagging."

A characteristic interest attaching to this tree is the profusion of very long catkins which appear in earliest spring, even before our native poplars are in bloom. They appear at Ithaca late in March or the first of April. The staminate or male catkins are particularly pleasing, and planters should select that sex, if possible. The illustration on the next page shows these interesting flower-clusters nearly full size.

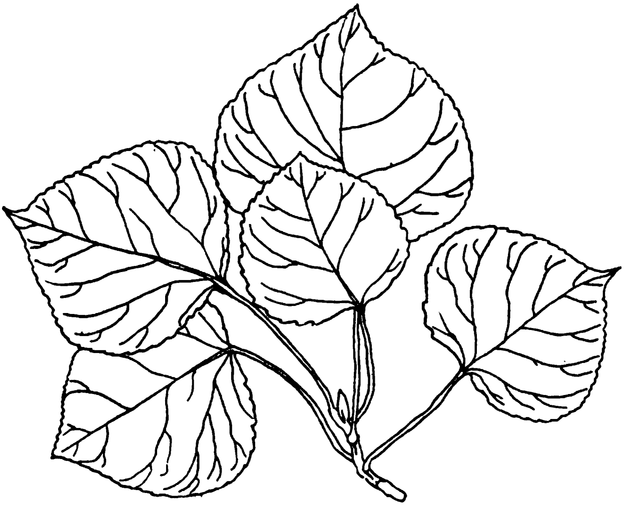


12. Populus grandidentata. (½ *nat. size.*)

9. **Populus grandidentata** (Michaux, Fl. Bor.-

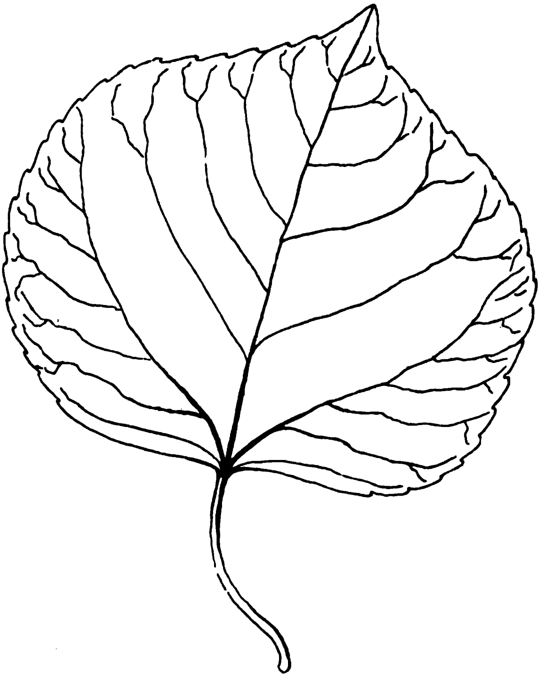

H. Lohmann

Am. ii. 243 (1803). *P. Græca pendula*, *P. nigra pendula* and *Parasol de St. Julien* of nurserymen). LARGE-TOOTHED ASPEN. Fig. 12; a, b, c, d, fig. 1.—This is a common native tree from Nova Scotia to North Carolina. It is distinguished from the European aspen, above, by much larger and thicker leaves which are bluish or rusty-white beneath, more ovate in outline, with larger and more spreading teeth, stouter leaf-stalks and larger leaf-buds. In its normal or erect form, it is rarely cultivated, but the weeping varieties, under a variety of names, are frequently seen. Most, and perhaps all of these varieties originated in Europe, where the tree, like the cottonwood and the common aspen, were early introduced. The habit of the tree is too stiff and the foliage most too heavy to make the best weeping subjects, however. One of the best of these weeping forms is that known as Parasol de St. Julien. The characteristic weak or zigzag winter twigs of the weeping varieties of this species are shown in Fig. 1. A is the form sold as *P. grandidentata pendula;* b is Parasol de St. Julien, and this twig shows a flower-bud midway. These two forms, it will be seen, have a stiffer or straighter habit than the two following. C is the form sold as *P. Græca pendula*, and d the one called *P. nigra pendula.*



14. Populus tremuloides (⅔ nat. size).

10. **Populus tremuloides** (Michaux, Fl. Bor.-Am. ii. 243 803). *P. trepida*, Willd. Sp. Pl. iv. 803. *P. Græca* and *Atheniensis* of horticulturists). COMMON ASPEN or POPPLE. ig. 14.—This is the commonest of the American poplars, and it nges from Labrador to Kentucky, New Mexico and California. is the species hich springs up recent clearings. In aspect is much like the uropean Aspen *P. Tremula*), but e leaves lack entirely the deep teeth f that species and ey are green on e under side. The atkins are also maller, and there re other botanical ifferences. There re no horticultural arieties of this pecies, so far as I now; but the lant is worthy at- ention from planters, as already indicated (page 208).



15. Populus Sieboldi (*⅔ nat. size*).

11. **Populus Sieboldi** (Miquel, Ann. Mus. Bot. Lugd. iii. 9. *P. rotundifolia* of American nurserymen). Fig. 15. A apanese species with foliage somewhat like the last only much arger and whitish below. Professor Sargent says* that "this ree is not rare in southern Yezzo, where it grows to the height of wenty or thirty feet, springing up in considerable numbers on ry, gravelly soil." The species is little known in this country. t makes a tree of spreading habit, with rather dark and heavy oliage. It appears to be hardy in western New York.

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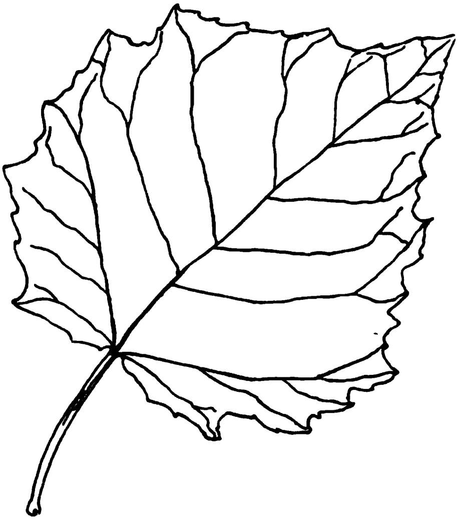
*_Garden and Forest_, vi. 404.

12. **Populus alba** (Linnæus, Sp. Pl. 1034 (1753). WHITE POPLAR, ABELE. A common European tree frequently planted in this country. Leaves much like those of *Populus grandidentata*, but smaller, usually thicker and more angular, the under surface—especially early in the season—woolly white. The straight, strong cylindrical winter shoots of this species and its varieties, with the very small buds, are shown at o, n, and m, in fig. 1.

The typical form of *Populus alba* is less grown here than the varieties with lobed and very white-bottomed (and occasionally variegated) leaves.

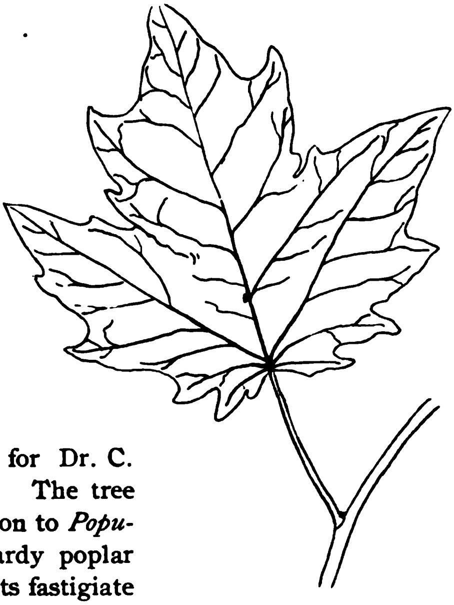
P. alba, var. **nivea** (Wesmael, DC. Prodr. xvi. 2d part, 324. *P. nivea*, Willd. *P. argentea* of nurserymen). This is the commonest form of white poplar in this country. It is known by the snow-white under surfaces of its foliage and the three or five lobed maple-like leaves. It is far too frequent about old yards, where its inveterate brood of suckers make it a perpetual nuisance. It is sometimes called Silver maple, from the resemblance of its foliage to that of the maple. The tree is so obtrusive in its character that it can rarely be used with good effect in home grounds. As a street tree in cities it is particularly offensive for the cottony covering of the under side of the leaves and of the shoots holds soot and dust, and it looks repulsively dirty. It is a misfortune that the tree were ever brought into the country, for few people appear to know how to make a considerate use of it.



16. Populus alba var. *canescens* (⅔ *nat. size*).

P. alba, var. **canescens** (Loudon, Encyc. 820). Fig. 16. Leaves broad or nearly circular in general outline, prominently notched but not lobed, the under surfaces and the young shoots very white-woolly. This tree is met with occasionally. Its horticultural value is not greatly different from that of var. *nivea*.

P. alba, var. **Bolleana** (Lauche, Wochenschrift der Deutsche Garten, No. 32, Aug. 10, 1878. *P. Bolleana*, Lauche, l. c.). BOLLES' POPLAR. Fig. 17. A very tall and narrow-topped tree, with cottony leaves rather more deeply lobed than those of the var. *nivea*. The tree was introduced into Europe in 1875 from Turkestan, and it was named for Dr. C. Bolle, an arboriculturist. The tree bears about the same relation to *Populus alba* that the Lombardy poplar bears to *Populus nigra*. Its fastigiate habit combined with the white foliage and shoots, make it a most emphatic tree and there is great danger of planting it too freely.



17. Populus alba var. *Bolleana* (*⅔ nat. size*).

INDEX TO SYNONYMS.

Populus angulata = P. monilifera.
Populus argentea = P. alba, var. nivea.
Populus Atheniensis = P. tremuloides.
Populus Bereolensis = P. laurifolia.
Populus betulifolia = P. nigra.
Populus Bolleana = P. alba, var. Bolleana.
Populus Canadensis = P. monilifera.
Populus canescens of some = P. alba, var. canescens.
Populus canescens of some = P. nigra, var.
Populus Carolina = P. monilifera.
Populus Carolinensis = P. monilifera.
Populus Certinensis = P. laurifolia.
Populus crispa = P. balsamifera, var. viminalis.

Populus dilatata = P. nigra, var. Italica.
Populus Dudleyi = P. balsamifera, var. viminalis.
Populus elegans = P. nigra, var. elegans.
Populus Eugenie = P. nigra.
Populus fastigiata = P. nigra, var. Italica.
Populus glandulosa = P. monilifera.
Populus Græca = P. tremuloides.
Populus Græca pendula = P. grandidentata.
Populus Hudsonica = P. nigra.
Populus Italica = P. nigra, var. Italica.
Populus laurifolia of some = P. balsamifera, var. intermedia.
Populus laurifolia of some = P. balsamifera, var. viminalis.
Populus Lindleyana = P. balsamifera, var. viminalis.
Populus macrophylla = P. candicans.
Populus nigra pendula = P. grandidentata.
Populus nivea = P. alba, var. nivea.
Populus Nolestii = P. balsamifera, var. latifolia.
Populus Ontariensis = P. candicans.
Populus Pannonica = P. nigra, var. Italica.
Populus Petrovski = P. laurifolia.
Populus Polonica = P. nigra, var. Italica.
Populus pyramidalis = P. nigra, var. Italica.
Populus pyramidalis suaveolens = P. balsamifera, var. viminalis.
Populus pyramidata = P. nigra, var. Italica.
Populus rotundifolia = P. Sieboldi.
Populus salicifolia = P. balsamifera, var. viminalis.
Populus Sibirica pyramidalis = P. balsamifera, var. intermedia.
Populus trepida = P. tremuloides.
Populus Van Geertii = P. monilifera.
Populus viminalis = P. balsamifera, var. viminalis.
Populus Wobsky = P. balsamifera, var. latifolia.

COMPENDIUM.

Landscape gardening is the embellishment of grounds in such manner as to secure landscape or nature-like effects. The style of planting, therefore, should be free and easy, devoid of all formalisms and unusual or forced effects. There should be broad open spaces of greensward and heavy masses, or groups, of trees and bushes ; and the heaviest plantings should be about the borders of the place. Scattered planting of individual trees and bushes is fatal to good effects. Trees which are simply odd or urious introduce irrelevant and jarring effects, and they should ever be made emphatic or prominent features of a place. Trees very unusual or striking character, as the Lombardy and Bolle oplars, must, likewise, be used with the greatest caution, and, oove all, their formality and strangeness should not be enforced y planting them in rows, in rural places.

The poplars are examples of trees which should be used only r secondary or incidental effects in landscape gardening, and ever to construct the body or main features of the planting. heap trees produce cheap effects.

The Lombardy poplar may be used to advantage now and then a group of trees to add spirit and vigor; but it should rarely e seen as an isolated specimen. The tree is used indiscriminately, ecause it grows rapidly in all situations and because its oddity leases many people. It is so much abused that its legitimate alue is obscured.

The varieties of the white poplar or abele are, in general, even ss desirable than the Lombardy. As ordinarily planted, they re immodest and ugly trees, especially the whitest varieties, and eir use in farm yards, country cemeteries and all small places hould be discouraged.

Poplars which should be encouraged for ornamental planting re the common cottonwood, the common wild aspen, the normal erect form of the large-toothed aspen, the Certinensis poplar, opulus elegans of the nurseries, and the European aspen.

Poplars of particular value for shelter belts and timber are the ertinensis, cottonwood, balm of gilead, and possibly Populus imonii.

Species of rather heavy and dark foliage and strong growth, nd which may be used for groups or masses, are the balm of lead, Nolestii, and probably Populus Sieboldi and P. Simonii.

Among the species and varieties which are interesting because natural peculiarities and which may be used for incidental fects or as single specimens, are Populus angustifolia, various rms of the balsam poplar (especially the variety viminalis), and rms of the European black poplar.

Weeping varieties are found in several species. The best is robably the drooping form of Populus Tremula, the European aspen. There are good weeping forms of the large-toothed aspen (Populus grandidentata), but they are apt to be too stiff for the best effects in a drooping tree. There are yellow-leaved or variegated forms of some species, of which the best is the variety of the cottonwood known as Van Geert's golden poplar.

The best single species of poplar for general planting in New York, is probably the common cottonwood or Carolina poplar (Populus monilifera). The second choice is the new Russian species known as Populus Certinensis (properly P. laurifolia).

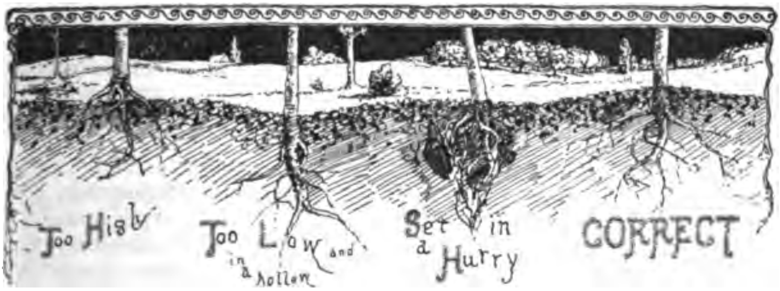
L. H. BAILEY.

Bulletin 69. **August, 1894.**

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

Hints on the Planting of Orchards.



By L. H. BAILEY.

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M. V. SLINGERLAND,	Entomology.
GEO. C. WATSON,	Agriculture.
G. W. CAVANAUGH,	Chemistry.
E. G. LODEMAN,	Horticulture.
MICHAEL BARKER,	Horticulture.

Office of the Director, 20 Morrill Hall.

Those desiring this Bulletin sent to friends will please send us the names of the parties.

BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.

CORNELL UNIVERSITY, ITHACA, N. Y.
AUGUST 15, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: I submit the following suggestions on the planting of orchards for publication under Chapter 675, Section 87, of the aws of 1894. The information which is here presented is in almost constant demand by the farmers of the state.

L. H. BAILEY.

THE EXPERIMENT STATION EXTENSION, OR NIXON, BILL.

A law has been passed by the legislature and signed by the Governor, providing, amongst other things, an appropriation of $8,000 to be expended by Cornell University for the benefit of horticulture in the Fifth Judicial Department of the State—an area comprising the counties of Cayuga, Seneca, Yates, Steuben, and counties to the westward. This fund is to be expended "in conducting investigations and experiments in horticulture; in discovering and remedying the diseases of plants, vines and fruit trees; in ascertaining the best means of fertilizing vineyard, fruit and garden plantations, and of making orchards, vineyards and gardens prolific; in disseminating horticultural knowledge by means of lectures or otherwise; and in preparing and printing, for free distribution, the results of such investigations and experiments, and such other information as may be deemed desirable and profitable in promoting the horticultural interests of the State." This work is to be prosecuted by Cornell University "under the general supervision and direction of the Commissioner of Agriculture."

Owing to the lateness of the passage of the bill, few definite lines of experiment could be undertaken the present season, but efforts are making in investigating the conditions and enemies of fruits and gardens, and especially in collecting and publishing the actual results of spraying orchards and vineyards. It is desired that any person or community which suffers an outbreak of any serious enemy shall communicate the fact to the undersigned, and, if possible, an expert will be sent to make an investigation. The causes of the failures of apple orchards is now the subject of a special investigation, and any person who has made experiments in spraying or fertilizing apple trees should advise us of the fact, in order that the results may be incorporated in the final report. Experiments are also in progress in various places in the fertilizing of orchard lands, and in other directions, the results of which will appear as they mature.

L. H. BAILEY, *Officer in Charge*,
ITHACA, N. Y.

APRICOTS IN WESTERN NEW YORK.

I. CULTIVATION OF THE APRICOT.

It is a prevalent notion that the apricot tree is too tender to be grown in New York State. It will surprise many to learn that the fruit is considerably grown in the State, there being one plantation of many hundred trees. The apricot is as hardy as the peach, and it thrives in the same localities and under the same general cultivation and treatment. There are three chief reasons, I think, why the apricot has remained in comparative obscurity in the horticulture of Western New York: 1. Ignorance of the fruit; 2. Loss of crop by spring frosts, because of the very early season of blooming of the apricot; 3. The fondness of the curculio for the fruit. To these may be added the fact that we have not yet arrived at an understanding of the best stocks upon which to bud the apricot; but this difficulty may be expected to disappear as soon as greater attention is given to the fruit and our nurserymen begin to propagate it extensively. Aside from the above difficulties, there are probably no reasons why apricots should not be grown in Western New York as easily as plums or peaches.

The apricot is a fruit somewhat intermediate between the peach and the plum. The tree is a round-headed, spreading grower with dark somewhat peach-like bark, and very broad or almost circular leaves. The fruit, which generally ripens in advance of both the peach and plum, is peach-like in shape and color, with a smoother skin, rich yellow flesh and large flat, smooth stone. The flesh is commonly less juicy than that of the peach, and, as a rule, perhaps, of higher quality.

The ideal soil for the apricot seems to be one which is deep and dry, and of a loamy or gravelly character. The rolling loamy lands which are well adapted to apples seem to be well suited to the apricot, if the exposure and location are right. The apricot seems to be particularly impatient of wet feet, and I am inclined to regard many of the failures with these trees as due to retentive subsoils. Wickson* thinks that some of the failure with this fruit in California "has been chiefly because they do not thrive under the summer irrigation system." I am convinced, also, that much of the uncertainty concerning the proper stocks for the apricot arises from too little consideration of the effects of different soils.

Particular attention should be given to the location and exposure of the apricot orchard. In this state, the best results are obtained if the plantation stands upon elevated land near a large body of water, for here the spring frosts are not so serious as elsewhere. Generally, a somewhat backward exposure, if it can be obtained, is desirable, in order to retard blooming. Apricots will be sure to fail in frosty localities.

The apricot should always be given clean culture. For the first two or three years some hoed crop may be grown between the trees, but after that they should, in general, be allowed the entire land, particularly if set less than twenty feet apart. Cultivation should be stopped late in summer or early in the fall, in order to allow the wood to mature thoroughly. The trees are pruned in essentially the same way as plums.

The question of the best stocks for the apricot is in dispute. It is commonly said, in this state, that the apricot is less successful upon its own roots than upon either the peach or plum. It is evident that it must be some unnatural or uncongenial condition which renders a tree unprofitable or short-lived upon its own roots; and I am inclined to believe that this condition is a cold, hard or poorly drained soil. "For deep, rich, well-drained, loamy soils, the apricot on its own root makes a magnificent tree," says Wickson.* "When it is desired to grow the apricot in moister and heavier soils, or where a light soil is underlaid by a heavy, retentive subsoil, recourse should be had to the plum root." "Budded on the peach root, it may be grown successfully on the light, warm, well-drained loams in which the peach delights." In California the peach is evidently most commonly used as a stock. In New York, both peach and plum—either common plum or myrobalan—are used, and apricot on apricot is practically unknown. The trouble with the peach and plum stocks is that the union is apt to be imperfect and to break under stress of wind. Apricots on apricot have been tried and are found to be short-lived ; and this fact, I am convinced, is mostly or wholly because our soils are generally not adapted to the apricot root. John Rock, of Niles, California, a well known and respected authority upon nursery matters, writes me concerning stocks for apricots, and his statements are all the more valuable in this connection from the fact that he has had much experience in New York state :

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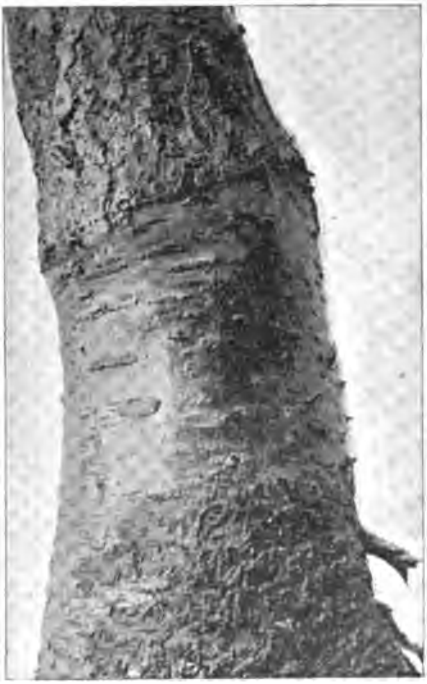
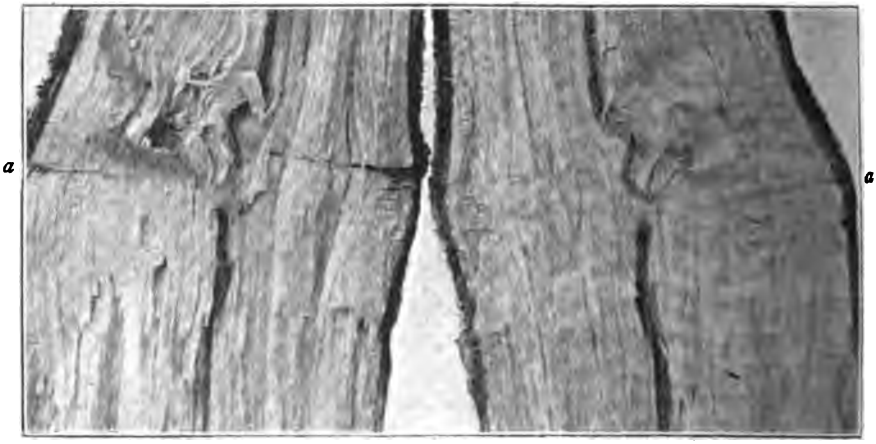
* California Fruits, 249.

"We use peach, apricot and myrobalan for stocks for apricots. Peach is best suited to deep rich alluvial soil, apricot for heavy adobe and gravelly soils, and myrobalan for heavy soil that is too wet for apricot or peach roots. The union on peach is always good with us. On myrobalan the union is not so good, and some trees will break off. Trees are more liable to break at the union when budded late in the season, when the sap has stopped flowing. Buds cut too heavy and not tied firm, make a weak union, as a callus forms behind the bud and pushes it off."



1. Union of Moorpark Apricot with peach root.

We frequently lose trees on peach roots without any visible break at the union; but an examination under the bark will usually show a line of separation between the peach and apricot. Fig. 1 shows the union of a Moorpark apricot, which mysteriously yellowed and died. When split open, the union presented the appearance shown in Fig. 2, in which it will be seen that the peach and the apricot had broken apart, in the direction *aa*. The break is particularly apparent in the left-hand section. This tree had been girdled from the breaking away of the cion and stock.

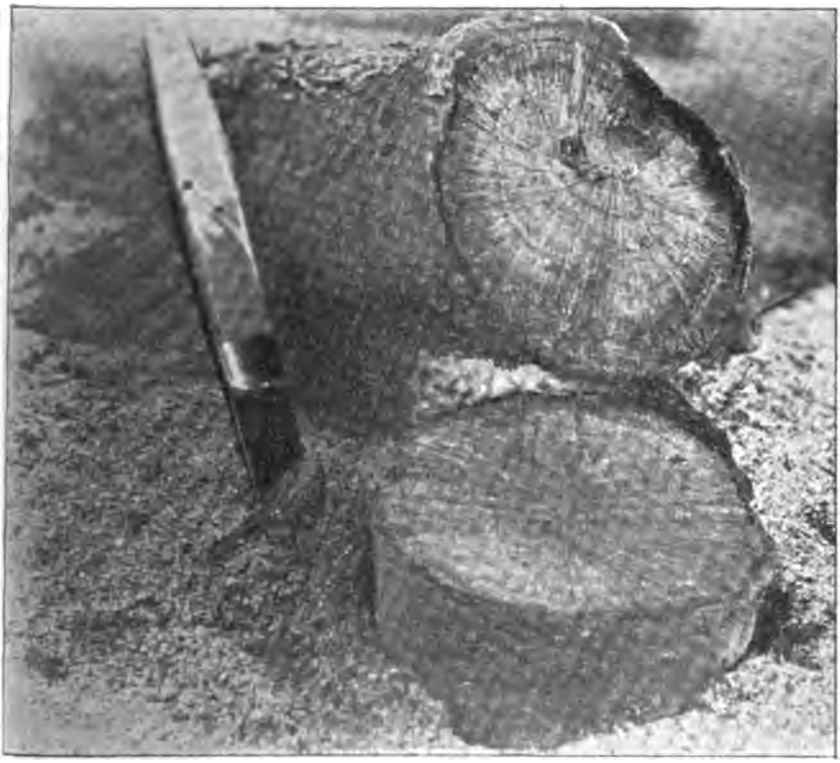


2. Same union as Fig. 1, split lengthwise and showing the divorce of cion and stock.

Myrobalan stocks have behaved no better with us. Fig. 3 shows how a Harris apricot tree broke off the myrobalan root with a clean and smooth fracture, showing that there was no real affinity between the two.

E. Smith & Sons, whose apricot orchard on Seneca Lake is the largest in the state, tell me that they have had trees break when nursery-budded upon peach and plum; but apricots on apricot roots have never broken, although such trees have died more freely than any other, a circumstance which is probably to be attributed to uncongenial, hard soil.

The question of the best stock for apricot in this state is yet under experiment. My own opinion of the matter, after much study of the subject, is this: Apricot is the ideal stock for apricots upon soils which are well suited to it,—those which are deep and loose and rich and well-drained. There are comparatively few lands of this character, however, and it is probably much safer to rely upon other stocks, particularly as our winters are so long and the ground becomes so thoroughly saturated with water. For the stiffer lands, plum stocks will usually be found to be safer, and I am inclined to favor top-worked stock—that is, plum trees top-budded or grafted in the orchard—rather than nursery-budded



3. Broken union of Harris Apricot on Myrobalan Plum.

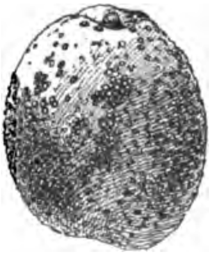
trees. On all the lighter and drier soils,—and these will probably comprise the greater part of lands devoted to the apricot—the peach, nursery-budded, will probably be found to be the best. In order to prevent the unions of nursery-budded trees from breaking, the trees should be set low, so that, if possible, the union is below ground; and this is especially important with the peach stock in order to escape injury from the borer. It will also be found to be advisable, no doubt, to head in the tops more or less, to prevent them from exercising too much leverage. With these conditions and precautions fulfilled, there need be only very small loss of orchard trees from poor unions.

The apricot, when grown under the best conditions, may be considered to be nearly or quite as productive as the peach. Like other fruit trees, it bears in alternate years, unless the crops are very heavily thinned. New York apricots are of superior quality and are popular in markets where they are known. They are to be considered as a dessert or fancy fruit, and should, therefore, be neatly packed in small and tasty packages. Under the right conditions and with careful attention, the apricot is, no doubt, destined to become a profitable fruit in this State; but it can never be recommended for general or indiscriminate planting. Only the best fruit-growers can succeed with it.

The most serious enemy of the apricot is the curculio, the same pestiferous insect which attacks the plum and peach. It seems to have a particular fondness for the apricot, and as the fruit sets very early the crop may be expected to be destroyed unless the most vigilant means are employed of fighting the insect. The best way to dispose of the curculio in apricot orchards is to catch him. Spraying with arsenical poisons is uncertain. The insect must be caught by jarring the trees, in the same manner as on plums and peaches, but the work must be even more thoroughly done than upon those fruits. The jarring should begin as soon as the blossoms fall and continue as long as the insects are numerous enough to do serious damage. It will usually be necessary to catch the insects for four or six weeks, two or three times a week, or perhaps, even every day. The work must be done early in the morning, while the curculio is indisposed to fly. It is said by some growers that the curculio is really more fond of the plum than the apricot, but that the apricot suffers more because of its earliness. These persons recommend the planting of plum trees amongst the apricots to attract the insects, upon which they can then be caught in great numbers.

It is presumed that the reader is acquainted with the methods of catching the curculio; but it may be well to say that the operation consists in knocking the insects from the tree by a quick jar or shake, catching them upon a white sheet or in a canvas hopper. The "catcher" most commonly used in Western New York (manufactured by J. B. Johnson, Geneva), is a strong cloth hopper mounted upon a wheelbarrow-like frame, and running upon two wheels. The hopper converges into a tin box, into which the curculio roll as they fall upon the hopper. One man wheels the devise, by barrow-like handles, under the tree, then drops the handles and jars the tree; or sometimes two men go with a machine, one wheeling it and the other jarring the trees. There are other devices for catching the curculio, but this is the most satisfactory one which I know.

The apricot has no other serious enemies in New York state, so far as I know. There is sometimes a spotted surface upon the fruit, appearing when the fruit is nearly grown and making a blemish, but not interfering with the quality. It is possible that there is more than one origin of these blemishes, but the causes have not yet been determined, although they are probably due to fungi. On most varieties, the trouble does not appear to be serious. Fig. 4 shows a spotted green fruit, natural size. In this particular disease, the spots are elevated like small red pimples. There is also a leaf-spot on apricot trees which may be associated with some of this surface injury of the fruit.



4. *Apricot Spot.*

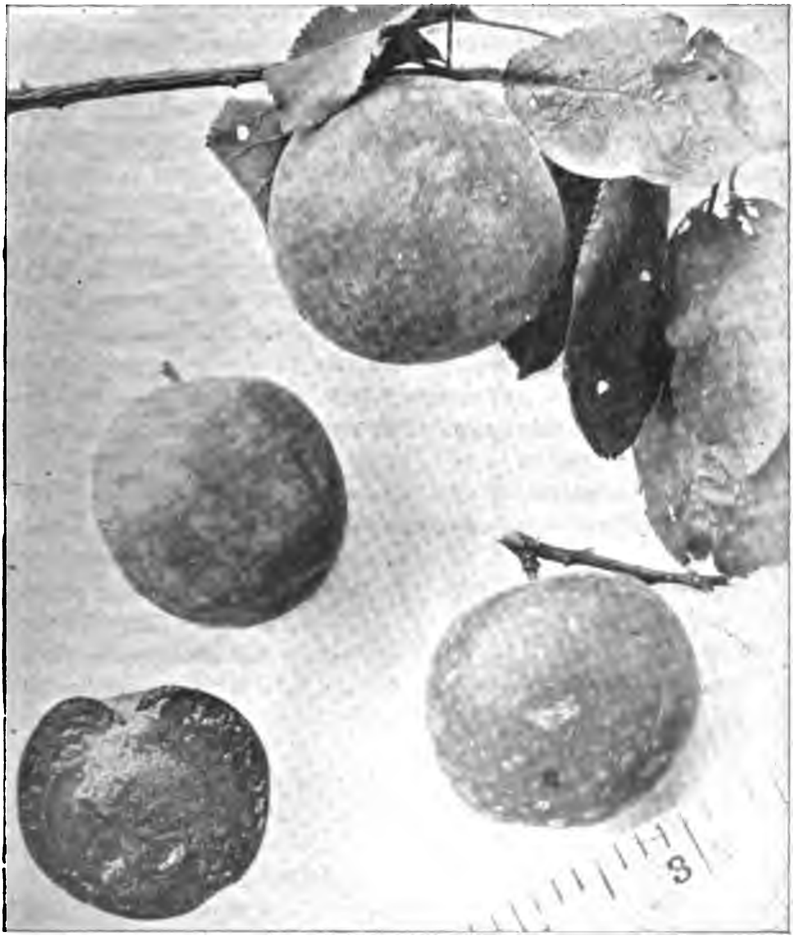
Thus far, I have written of the cultivation of the apricot in orchards. The fruit is well adapted to training on walls and buildings, however, where the peculiar excellence of the fruit fully develops even in otherwise unfavorable localities. There is great danger, however, of too early bloom if the trees are set upon south walls. Hon. James Wood, of Mount Kisco, has had unusual success with trained apricots, and he has kindly given me his experience :

"I have been successful in growing apricots during the past twenty years, never having failed in securing a fair crop during that time. My trees are trained to the northwest walls of a building something over 100 feet in length. The trees are eight feet apart and are trained to a height of ten or twelve feet. All projecting limbs are cut off and those that can be secured to the wall are trained so as to cover it as completely as possible. The varieties grown are Moorpark, Peach and Alberge de Montgamet. The Moorpark is of the highest quality but the trees are deficient in vigor and are rather shy bearers. The Peach apricot is a heavy bearer and the fruit is of excellent flavor but of rather small size. The Alberge de Montgamet has large and handsome fruit,—the showiest of any I have seen grown in America—but the quality is not equal to the others. The trees are very vigorous. In another place I have a number of trees of the Purple apricot. The fruit is quite acid and I know of nothing to recommend it. The fruit rots badly before ripening. There are two advantages in the northern exposure : the blossom buds are kept back in spring, and a larger crop of fruit sets in the later blooming ; and the cooler and moister conditions during the development and ripening of the fruit ensure more uniform results."

II. VARIETIES OF APRICOTS.

There are three species of true apricots in cultivation in Western New York ; and to these might be added the apricot plum, *Prunus Simonii*, a sufficient discussion of which was given in our Bulletin 51. These three species of apricots, to which we must give attention at this place, are the Purple (*Prunus dasycarpa*), the Chinese or Japanese (*P. Mume*), and the common and Russian apricots (*P. Armeniaca*). These species may be distinguished as follows :

I. PRUNUS DASYCARPA. PURPLE OR BLACK APRICOT.—Fruit (Fig. 5) globular and somewhat plum-like, with a distinct stem, pubescent or fuzzy even at maturity, dull dark purple, the sourish soft flesh clinging to the plum-like fuzzy stone. Tree round-headed, with much the habit of the common apricot, with



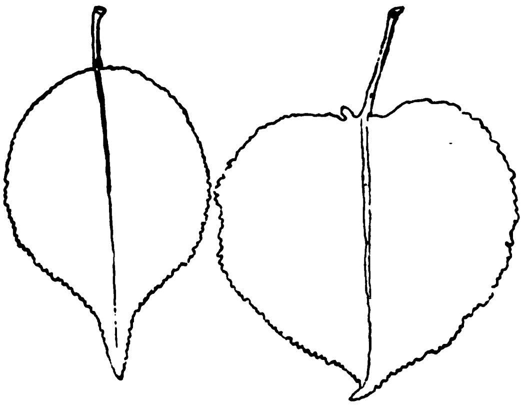
5. *Purple Apricot* (*Prunus dasycarpa*). *Natural size.*

leaves ovate and more or less tapering at both ends, thin, dull green, on slender and pubescent mostly glandless stalks, finely appressed-serrate, and hairy on the veins below. Flowers large and plum-like, blush, solitary or in twos, on pubescent stalks a half inch or more long, and appearing in advance of the leaves.

The nativity of the Purple apricot is unknown, but the species is probably Asian. The fruit has been long cultivated in this country, but the quality is inferior and the color unattractive, and it has never become popular. The fruit is shown natural size in Fig. 5. As grown in Western New York, it is uniform dull red in color, like a blood peach. The flesh is red, soft and somewhat fibrous, juicy, sub-acid, sour and a little bitter about the pit. The quality must be considered low, although it has a refreshing flavor. The fruit ripens with the latest apricots. The specimens figured in Fig. 5 were picked Aug. 9, 1893. "This remarkable little apricot," Downing writes, "so strongly resembles a dark round plum that at a little distance it might easily be mistaken for one. It is pretty good, and very hardy, and its unique appearance renders it sought after by amateurs."

The stalked plum-like flowers of this species are shown in the upper spray on the title page. The lower spray shows the flowers of the common apricot.

II. PRUNUS MUME. CHINESE OR JAPANESE APRICOT. Fruit (Fig. 8) small, yellowish or greenish, the flesh rather hard and dry and adhering tightly to the pitted stone. Tree like the common apricot but with a grayer or greener bark and duller foliage; leaves grayish-green, generally narrower (Fig. 6) and long-pointed, more or less hairy along the veins below and on the shorter mostly glandless stalk, thick in texture and prominently netted beneath. Flowers fragrant, borne singly or in twos and sessile (without stalks).



6. *Leaves of Prunus Mume (left), and common apricot (right). One-half natural size.*

Japan. Recently introduced to this country. Its chief representative here is the Bungoume, or so-called Bungo plum. Other forms of this species in this country are the Hanahoumie, Koume, Gold Dust and Chinese Apricots. I have also seen it growing under the name of Hattonkio plum; and one of our leading northern nurserymen sold me a tree of it under the name of Myrobalan plum! The form of leaf of this Japanese species is contrasted with that of the common apricot in Fig. 6; and the fruit and foliage of the variety known as Bungoume is shown in Fig. 8.

The Bongoume is the only variety of this species which I have known to fruit in New York. The fruit is small and poor, and I do not see sufficient merit in it to make it worth growing. P. J. Berckmans, of Augusta, Georgia, writes me that the Bongoume has fruited but once with him, although he has had the variety several years. It usually blooms in February, and the flowers are destroyed by frosts. "I am satisfied," he says, "that this type of fruit is worthless where the orange is not perfectly hardy." But in common with some other plants which are injured by spring frosts in the South, this species often escapes in the North because of the absence of unseasonable "warm spells" which, in that region, start the buds.

This species (*Prunus Mume*) is really more valuable for ornament than for fruit, and for this purpose it is chiefly grown in Japan. Double-flowered varieties are also known in this country. Professor Georgeson, who has made a particular study of fruits in Japan, writes* as follows concerning this apricot, or plum, as he calls it:

"PRUNUS MUME. *Ume* and *Mume* of the Japanese. The fruit-bearing varieties of this species do not take a high rank; in fact, the fruit appears to be an incidental product rather than the main aim of their culture. This is the parent of the hundreds of varieties of the flowering plum, and the trees are cultivated for their flowers. The Japanese entertain a love for their plum flowers which is akin to passionate adoration. They are cherished alike in the poorest hut and in the princely mansion.

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* American Garden, xii. 76 (1891.)

No door-yard is too small or park too grand to afford space for the humble, cheerful, fragrant plum flower. The early varieties begin to bloom soon after New Years in the latitude of Tokio, and from then until the end of March a succession of bloom is kept up by the different varieties. The flowers vary in color from white through innumerable shades to dark red, and from single to very double.

"As stated, the fruit is generally secondary to the blossoms, but there are, nevertheless, several varieties which are grown, partly at least, for the fruit. They have been divided into two classes, based upon the size of the plums, namely, large-fruited and small-fruited. The following named kinds belong to the large-fruited class: Yoro, Hana-ka-mi, Bungo, Katayama-bungo, Kashiwagi, Naniwa-rinshiu, Yatsu-busa, Aujiku. Among the small varieties the following may be named: Gariobai, Kobai, Robai, Ko-mume, Yoshino-ko-mume, Toko-mume, Kaga. As a matter of fact, nearly all of the flowering kinds also yield some fruit, especially those with single and semi-double flowers. All of these plums which have come under my observation have been perfectly round, and have varied from less than an inch to an inch and a half in diameter. In color, they are mostly green or greenish yellow, though some are white and others red. They are all short-stemmed, and cling closely to the branches, like the peach. The majority are cling-stones, and in the matter of quality they cannot compare with the varieties of true plum, *Prunus triflora*, being rather acid and lacking flavor. They are mostly gathered while green, and are made into *ume-boshi* by the simple process of pickling in salt."

III. PRUNUS ARMENIACA. COMMON APRICOT. Fruit variable, but smooth at maturity, red or yellow, the sweet and firm flesh free, or very nearly so, from the large, smooth, flat stone. Tree with a round, spreading top and a reddish, cherry-like or peach-like bark; leaves (Fig. 6) ovate or round-ovate with a short point and sometimes a heart-shaped base, thin and bright green, smooth or very nearly so below, as are the gland-bearing stalks, the margins rather obtusely and mostly finely serrate. Flowers pink-white and borne singly, sessile or very nearly so, preceding the leaves.

Native to Northern China, Mongolia and Mandshuria, but cultivated from the earliest times and once thought to have come from Asia Minor (whence the specific name, *Armeniaca* or Armenian). The species is cultivated somewhat in Japan for its fruit, and probably some of the Japanese varieties introduced into this country belong to it.

Professor Georgeson writes as follows of its cultivation in Japan: "The apricot is not indigenous, but has probably been introduced from China. It is, however, commonly known among the people, but is not extensively cultivated. It does not seem to be appreciated, and but little attention is paid to it. Andzu is the only native variety that has come under my observation, though there are undoubtedly others."

Russian apricots.—There are two general types of the apricot in cultivation in this country, the common type and the Russian. It has been repeatedly said that the Russian apricots belong to the species *Prunus Sibirica*, but this is an error. They comprise a race of the common or European apricot, *Prunus Armeniaca*, differing from the familiar sorts in having a narrower and rather darker leaf, and generally a smaller and inferior fruit. The Russian almond, sold by Lovett, is an apricot, but we have not yet fruited it.

The chief merit attributed to the Russian apricot is its hardiness; but my own experience, extending over about nine years, shows that in central Michigan and in New York the Russian stock is as likely to be injured as the common and better varieties. At Lansing, Michigan, a lot of about fifty strong two-year Russian seedlings from Nebraska were killed, most of them root and branch, while budded trees of Russian varieties alongside stood a year or two longer, yet these budded trees finally succumbed. I have always been at a loss to understand why the seedlings should have perished sooner than the budded trees (which were probably on peach roots); but I am inclined to think that the soil, although sandy, was uncongenial to the apricot roots. Here at Ithaca, in central New York, all apricots endure the climate perfectly, but our winters are less severe than at Lansing. Moorpark, Early Golden, and other common sorts endure our climate equally as well as the Russian varieties. If the Russian apricots are really hardier than the common ones, they should be widely disseminated upon the northern borders of our apricot region ; but where other apricots can be grown, most of these are scarcely worth serious attention.

We have a number of good trees of Russian apricots, set in 1888, and they have given us one very heavy crop of all varieties, and one very small one of some varieties The handsome little fruits hang in clusters and ropes on many of the trees, especially on Budd, Gibb, and Alexander. The catalogues have said that some of these Russians, especially the Catherine, are almost as early as strawberries, but none of ours have ripened before the last week in July, and Alexander and Gibb are several days later.

These Russian apricots were introduced into this country by the Mennonites, who settled in the West. They were grown in the country so long ago as 1876, and probably earlier. The Mennonites propagate the fruit from seeds alone, and a few of the resulting varieties have been secured and named by nurserymen. The G. J. Carpenter Co., Fairbury, Nebraska, writes me that "the named varieties, Budd, Gibb and Alexander, were first offered by us about ten years ago, and were a selection of the strain growing here among the Mennonites. This year [1893] our earliest varieties were ripe and gone before the 4th of July, and the Russian varieties were the only ones that gave us any fruit. Such varieties as Moorpark, Breda, and Early Golden had their buds killed by our severe winter." Professor Budd speaks* as follows of these fruits : "The Russian apricots we have never recommended. Even where the trees are hardy in central and south Iowa they do not bear, as they blossom too early. On the College grounds we have never grown half a dozen specimens of the fruit. The Shense apricot we recommend as the hardiest of all for Iowa, but this is not hardy north of the 42d parallel and, like all the apricots, it is slow in coming into bearing."

This Shense apricot, of which Professor Budd speaks, has not been fruited in this state, so far as I know. It is properly not a Russian variety. It comes from Northern China. It is also

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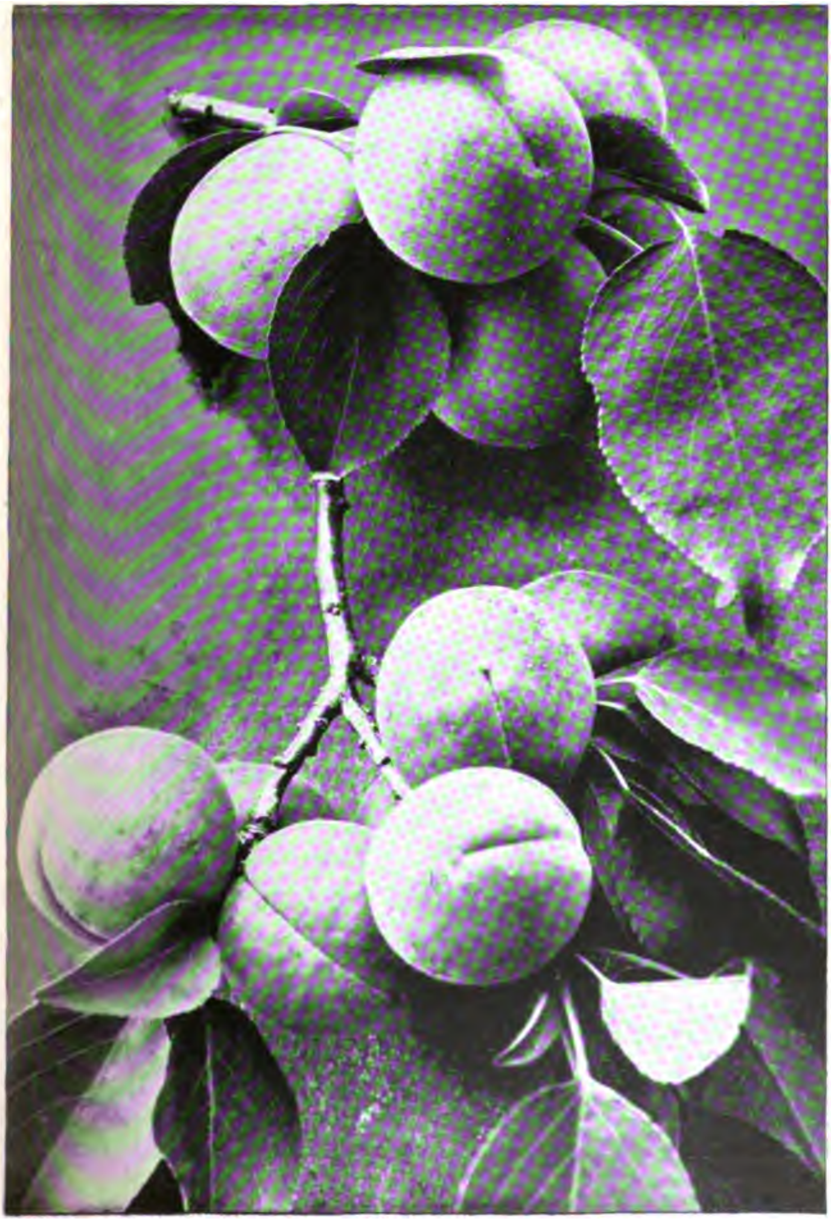
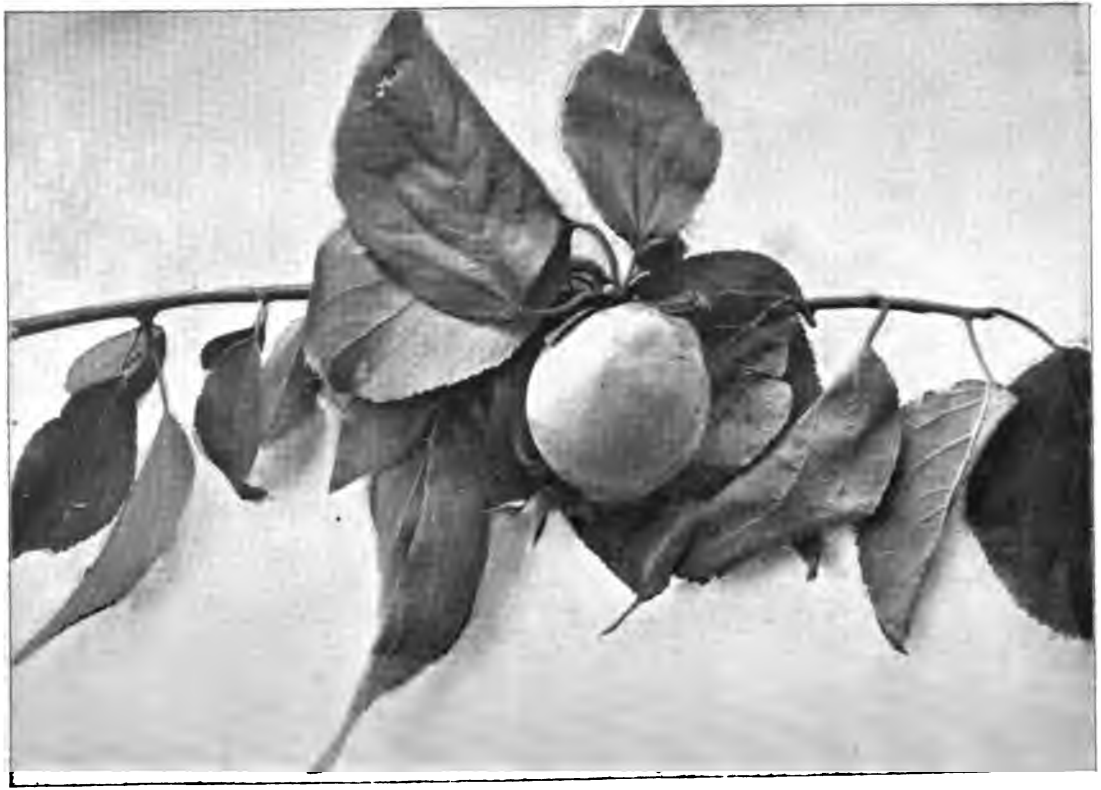
* Rural Life, July 5, 1894.



7. *Budd (above) and Catherine (below). Natural size.*



8. Bungoume Apricot (Prunus Mume). One-half natural size.

known as Acme, under which name it was introduced in 1890* by the G. J. Carpenter Co. Professor Budd writes me that "it endures drouth better than anything in the stone-fruit line on our grounds."

There appears to be some confusion amongst the varieties of Russian apricots, and I am not sure that the same name always represents one variety. G. J. Carpenter writes me that when they "first sent out these varieties, Budd had proved the earliest of any, followed closely by Catherine;" but with us Catherine is the earliest variety, followed closely by Budd. Alexis, which Mr. Carpenter considers to be the "largest and most valuable" of the Russians, I have not grown. The other varieties now offered by nurserymen have borne with us, and the following notes were taken in the field upon August 3, 1893:

Catherine, Fig. 7.—Early, fit to ship July 26, now all soft and ready to eat from the tree. Fruit small, slightly oblong-globular, deep rich orange, with a dull red cheek in the sun, rather dry in flesh and of indifferent quality, even for a Russian, and possessing three or four woody strings running along the angles or ventral side of the pit, which remain in the flesh and greatly detract from its value. Freestone. Average fruits measure three and one-half inches in transverse girth, and two to three of them weigh an ounce.

Budd, Fig. 7.—About the same as Catherine in season, or possibly a day later, oblong in shape, light orange in color, with only a very faint blush, if any. Flesh moderately juicy, with a sweet, peach flavor. Varies from cling to half cling. Evidently one of the best in quality of the Russians, but too small for market. Ripe with Early Golden, or only a day or two ahead of it.

Nicholas.—Some trees ripen with Budd, and others a week or ten days later. Fruit larger and fairer than Budd, oblong and more or less flattened. Flesh juicy and sweet, the pit free. There are evidently two kinds of this variety in our orchard, although the trees were all procured at the same time, from one nurseryman. The later trees bear larger fruit than the others, with a much larger and looser pit, and have a drier flesh. Probably Alexander is mixed with this in our orchard.

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* Annals Hort. 1890, 156.

Alexander.—About a week or ten days later than Catherine and Budd. Fruit small, oblong, and flattened, orange-yellow, with a faint blush cheek, the flesh firm and rather coarse. Pit larger and loose. This and the late form of Nicholas, mentioned above, seem to be the same thing. About the season of the Breda, with us.

Gibb.—Three or four days later than Catherine and Budd, and somewhat larger, oblong and flattened. Color a light lemon or white-yellow, with only a trace of color in the cheek. Flesh juicy and tender, but lacking in flavor, and somewhat acid. Pit rather large and loose.

These five are the only Russian varieties which we have fruited. None of them are as good either in quality or size, as Royal, Breda, Early Golden, and other varieties.

Some four years ago I made an inquiry into the history and merits of the Russian apricots, and the conclusions of that investigation* are still correct, so far as I know.

1. The Russian apricot is somewhat hardier than the peach, and may be expected to endure the climate a degree or two north of the peach belt.
2. It blooms early (like the common apricot) and is liable to injury from late spring frosts.
3. Seedlings vary widely, and many of them are worthless.
4. The fruit, even of the best sorts, is much inferior to that of the older and better known varieties of apricots.
5. There is promise of considerable improvement in the varieties under proper care and selection.
6. The fruit is particularly liable, in common with other apricots, to the attacks of the curculio, and in the West to the attacks of the plum gouger.
7. In general, it appears that on the northern limits of peach culture, the best varieties of Russian apricot are worth cultivation on a limited scale, but they cannot compete with other apricots in places where the latter can be grown.

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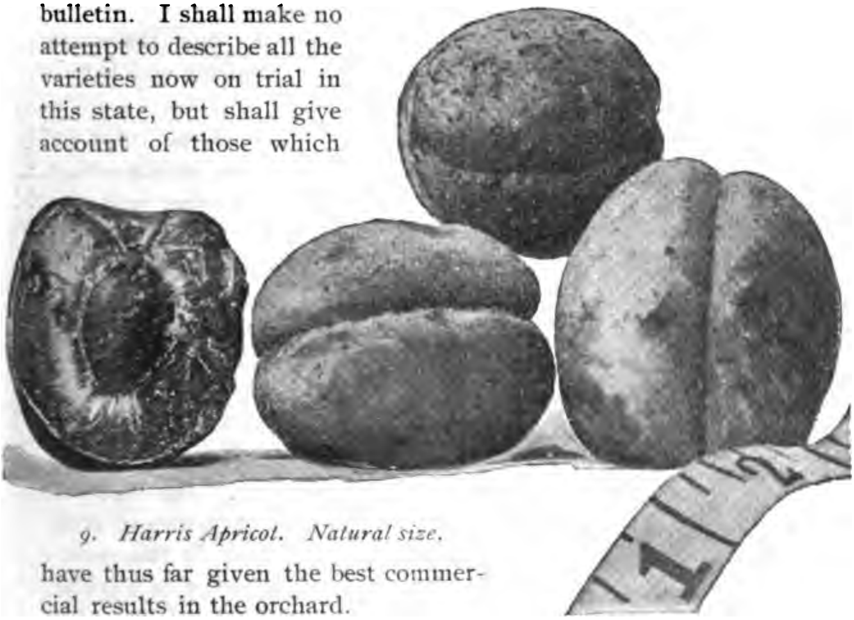
* American Garden, xi. 645.

The best apricots.—It is impossible, at the present time, to state with much confidence what apricots are best adapted to Western New York and its markets. Many varieties have been tried by various growers, particularly by E. Smith & Sons, Geneva, the most extensive apricot growers in the state, and to whom I am greatly indebted for much of the information contained in this bulletin. I shall make no attempt to describe all the varieties now on trial in this state, but shall give account of those which have thus far given the best commercial results in the orchard.



9. *Harris Apricot. Natural size.*

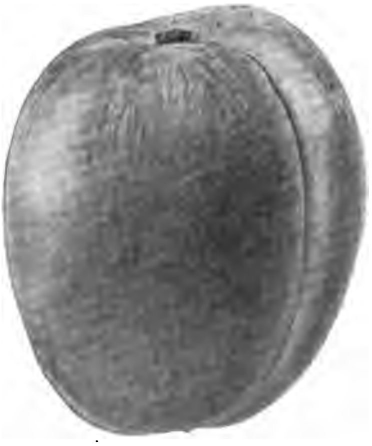
Early varieties.

Smith's Early.—A flattish apricot of medium size, or even large for an early variety, ripening from the 1st to the 10th of July. It is ordinarily very productive, and the quality is good. The origin of this variety is unknown. The original tree was growing in a yard in Geneva when the place passed into the hands of William Smith. The variety began to be propagated about ten years ago.

Harris (Fig. 9).—I am entirely unable to determine if the Harris and Smith's Early are distinct. Last year I thought them the same, but this year I thought that I saw some fairly constant differences in the fruit; but if not perfectly identical, they are so much alike that they cannot be distinguished by printed descriptions. The Harris is also the product of a single tree found in a Geneva yard, the property of Edwin Harris. The variety was first propagated about the same time, or perhaps somewhat earlier, than the Smith's Early. It is probable that both varieties are some English sort of which the name has been lost. The Harris is a poor grower in the nursery, and it is not yet sufficiently tested to enable me to recommend it. But these two varieties constitute the best type of very early apricots which have yet been grown in Western New York.

Early Moorpark.—A rather small apricot, in shape, color and quality resembling the Moorpark, but about three weeks earlier. It is productive, and of better quality than the above varieties, but its small size is against it for a general market fruit.

St. Ambroise.—A well known large early apricot, of flattish shape, and deep yellow color, reddish in the sun, of excellent quality. It is a favorite variety in England, and is said by Hogg* to be "the most prolific variety in cultivation."


10. Turkish of Western New York. Natural size.

Mid-season and late varieties.—Turkey or Turkish (Roman?)—One of the very best of the apricots grown in Western New York is the variety known as Turkey or Turkish, and shown natural size in the engraving (Fig. 10). It is a very large, flattish and elongated fruit, with a rich orange ground shaded with red, and a firm, good flesh. The tree is a very strong grower, the foliage dense and dark, and it is very productive. This variety is very like the Montgamet, except that it is a week or two earlier.

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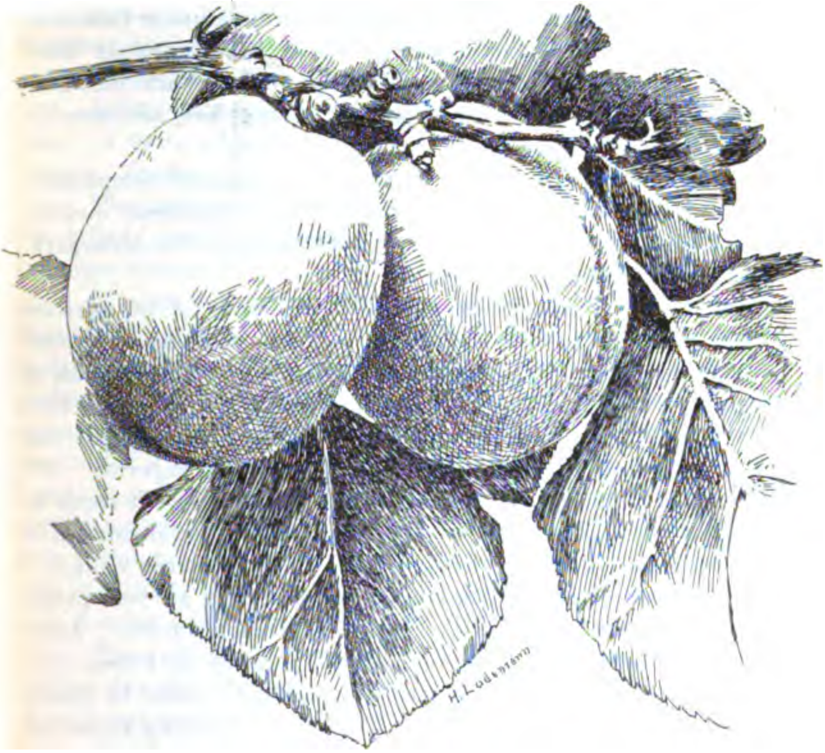
* Fruit Manual, 5th ed. 272.

It is probable that this apricot is improperly named, for the Turkey of the fruit manuals is said to be very late, ripening even after Moorpark, whilst this variety is probably two weeks earlier than Moorpark. Both Downing and Hogg describe the Turkey apricot as medium size, round, not compressed, and Downing says that it "is a fine old variety which is seldom seen in our gardens, the sort generally sold under this name being the Roman." Wickson* says that the Turkey is "commended by Southern California Nurserymen's Association as good for home use, but too juicy for canning or market"—a description which will not fit our variety.



11. Roman Apricot. Natural size.

The Roman is also grown in Western New York, and it seems to be the same as the above. Fig. 11 shows specimens of average size grown under this name. I have not seen an apricot in this region which seems to answer to the characters of the Turkey.

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*California Fruits, 260.

Montgamet (*Alberge de Montgamet*).—An old variety, and apparently one of the most productive and best market apricots yet tested in the State. The variety grown here under this name is much like the Turkish described above, but somewhat later. Smith's Triumph, originated with W. W. Smith, Vacaville, California, is very much like the New York Montgamet, and possibly indistinguishable from it.

Royal.—A French variety of large size, slightly compressed, with a dull yellow skin and a red cheek, of excellent quality. One of the best, ripening about a week ahead of the Moorpark. Likely to overbear.

Moorpark.—This is probably the best known of the apricots grown in the North,in this country. It is the latest one yet proved in Western New York, ripening from the 10th to the middle of August. The fruit is large to very large, with a light orange skin and deep orange or orange-red blush in the sun, compressed, one side usually larger than the other. The quality is superior. Altogether, it is one of the very best of all apricots, and it seems to be a heavy bearer in Western New York, although Downing says that "it is only a moderate bearer here [Hudson River Valley]."

Amongst the varieties less known, the following are very promising for Western New York: Luizet, a French variety; Jackson, originated on the farm of Andrew Jackson, in Fresno Co., California; Allison, a seedling of White Royal, raised by Josiah Allison, near Vacaville, California; Eureka, a seedling grown by I. H. Thomas, Tulare Co., California.

REVIEW.

1. The apricot is adapted to cultivation in Western New York, and it is already grown to a commercial extent.

2. The chief general difficulties in the way of its cultivation, aside from ignorance concerning the fruit, are the habit of early blooming and consequent liability to injury by late spring frosts, and the ravages of the curculio.

3. Injury from frost is to be avoided by choosing frostless locations, as those adjoining bodies of water, and by avoiding too "early" lands.

4. The curculios can be kept in check when they are caught and killed; and this is best done by jarring them onto sheets, in the same manner long followed in plum and peach orchards.

5. It is not yet certain what are the best stocks for apricots in Western New York. It is probable that no one stock is best under all circumstances. The apricot root itself seems to be impatient of our cold and wet soils, which are drenched by the drainage of winter. It needs a very deep and rich soil, but it is doubtful if it is safe for this state. The common plum (not myrobalan) is an excellent stock for plum soils, and the apricot does well either nursery-budded or top-worked upon it. Peach is probably the commonest stock, and for peach soils it is probably the best that can be used. If the apricot thrives upon various stocks, it is thereby adapted to many soils.

6. The cultivation, pruning and care of the apricot are not unlike the attention given to the peach; and it may be expected to be about as productive as the peach.

7. There are three species of apricots in cultivation in Western New York,—the Black or Purple, the Japanese or Chinese, and the common types.

8. The Black or Purple apricot (*Prunus dasycarpa*), of unknown nativity, is a fruit of comparatively small merit. The fruits are round and plum-like, stalked, fuzzy, very dark red in skin and flesh, the latter soft and subacid and clinging tightly to the pit. It is not grown for market.

9. The Japanese or Chinese apricot (*Prunus Mume*), native to Japan, is represented in this state chiefly by the Bungo or Bun-

goume. It differs from the common apricot in peculiarities of foliage, fragrant flowers which are double in many ornamental varieties, and small, hard clingstone fruits which are of little value.

10. The common apricot type (*Prunus Armeniaca*), originally from Northern China, comprises two groups,—the Russian and the common sorts.

11. The Russian apricots appear to be somewhat hardier than the ordinary type, but beyond this fact they appear to have no merit for Western New York; and the common apricots are sufficiently hardy here. The fruit is small and mostly poor, as compared with our standard sorts.

12. The varieties of apricot most prized for commercial planting in Western New York appear to be Smith's Early, Harris, Early Moorpark, St. Ambroise, Turkish (probably Roman), Montgamet, Royal, and Moorpark. Varieties less known but very promising, are Luizet, Jackson, Allison and Eureka.

L. H. BAILEY.

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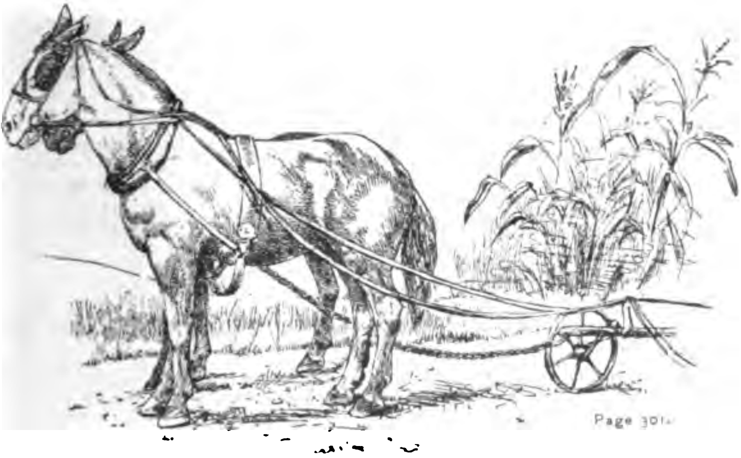
Cornell University Agricultural Experiment Station,
ITHACA, N. Y.

HORTICULTURAL DIVISION.

THE
Cultivation of Orchards.



By L. H. BAILEY.

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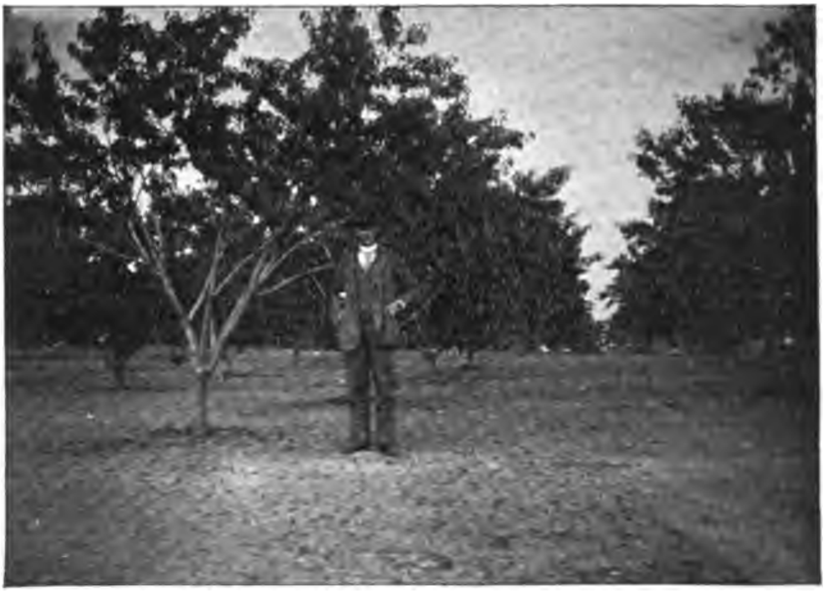
65. Tuberculosis in Relations to Animal Industry and Public Health.
66. The Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Popular.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.

CORNELL UNIVERSITY, ITHACA, N. Y.,
Sept. 1, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following sketch of the philosophy of the cultivation of orchards, a sequel to Bulletin 69, is submitted for publication and distribution under Chapter 675, Section 87, of the Laws of 1894.

L. H. BAILEY.



Ideal cultivation of peach orchards. The upper cut illustrates what I believe to be, in general, the best method of pruning peach trees.

THE CULTIVATION OF ORCHARDS.

There is probably no subject upon which pomologists differ so widely as the methods of cultivating orchards. These differences arise very largely from the different soils and circumstances of the various orchards, and it is useless to attempt to reduce them to one system of practice. Yet, whilst all advice touching the cultivation and management of fruit plantations must be subject to many exceptions and modifications, there are certain underlying principles which every fruit-grower must consider and which must form the basis of all operations.

The object of all cultivation is to furnish the plant with the best materials and conditions of growth. Plant-food must be supplied and moisture must be conserved. It should be remembered that the soil itself is the greatest storehouse of plant-food and that the first consideration of the farmer should be the attempt to utilize it. The application of plant-food in the form of farm manures or other fertilizers must be a secondary consideration. It should also be known that the very treatment which best utilizes the natural food resources of the soil, is also the best conserver of moisture. This treatment is tillage.

Preliminary considerations.—All subsequent treatment will fail of best results if the original preparation or selection of soils is imperfect or hasty. In the first place, the fruit-grower must be sure that his soil and location are adapted to the particular fruit he desires to plant. In the second place, the soil itself should be in good condition before the trees are set. Soils which enjoy perfect natural drainage are particularly desirable for orchards, because they are not only warm and give up their fertility easily, but also because they allow of very early cultivation, which is an important requisite in the management of orchards.

If this perfect natural drainage does not exist, tile-drainage should be employed, until the soil is brought into the best possible condition. It should be said that many hard and wet soils make excellent pear and plum lands when thoroughly tile-drained. It is a common opinion that only flat lands need draining, but one often finds rolling lands in which the subsoil is high and hard and holds the water like a dish-pan. Judicious draining not only carries off the superfluous water, but it also loosens the subsoil and allows it to retain its moisture better in times of drought. An attempt should be made to bring the land in the various parts of the orchard into conditions as uniform as possible, so that the same tillage and treatment may be applied to the entire area. All hard and "sour" spots should receive particular care in draining and subjugation, or they should be left outside the plantation. The present season has enforced the importance of good drainage in the orchards of New York to an extent which I have not known before. The spring was very wet and the summer has been very dry. In most orchards, cultivation began so late that the most assiduous attention during the later months has not been able to correct the delay, and the effects of the drought have thereby been intensified.

Theory of tillage of orchards.—The first object of tillage is to furnish plants with food. A fine physical condition of the soil allows the plant to reach every part of it, and aids greatly in unlocking and utilizing materials which are more or less unavailable.

But the advantage of tillage which I wish now to impress upon the reader, is its conservation of moisture. The first plowing or cultivation in the spring may be either shallow or deep, according to conditions; but the subsequent cultivation should be shallow and very frequent, in order to make a mulch of the surface soil. The best mulch—that is, the best conserver of moisture—is a frequently stirred, soft and fine surface soil. And all the grateful effects of this surface mulch are ordinarily most marked when the soil contains considerable vegetable fibre or humus, which, of itself, is a saver of moisture.

But if orchards should be plowed early in spring, it does not follow that they should be plowed in the fall. In fact, fall plowing is commonly to be discouraged, for it leaves the soil in an open and loose condition which may be injurious to the roots, and it often starts the trees too early in the spring. I know persons who plow vineyards late in the fall for the express purpose of starting an early growth and of securing an early crop; but this is safe only in those favored localities in which late spring frosts are practically unknown. Fall plowing may be advisable as a preparation for many farm crops, but in orchards better results are usually secured from cover-crops than from fall plowing. Cultivation should also generally stop late in summer or early in fall, as explained further on (page 305).

If the above propositions are true, it follows that the best results are obtained only when this treatment is applied from the start. It is in the first two or three years of the life of the orchard that the roots are strongly defected downwards under the influence of cultivation. Orchards should never be put into sowed crops or into grass for the first five years of their life, and grain crops should always be withheld. Everywhere one may see young orchards in wheat-fields or oat-fields, and the short growth, knotty bodies and yellow leaves tell the story of shallow roots, dry soil, borers, and all the ills which every farmer who follows such methods deserves to have fastened to his trees. A useful lesson upon the value of cultivation in conserving moisture is given on a following page (306), under the discussion of green manures. I am convinced that many of the apple orchards of New York state were ruined in their youth by just such methods, and that no amount of subsequent cultivation can send the roots down where they belong. The best treatment for many orchards in the state is extermination. If there is any profit in them, it is for fire-wood.

Cultivate the orchard from the first and begin the cultivation early. "But I don't have time; there is too much farm work to be done," I hear everywhere. Then do not plant the orchard! It is strange that farmers feel that if anything is to be neglected it must be the orchard. Perhaps it would be well to put the most attention upon the most profitable part of the farm, and as likely as not this part will turn out to be the orchard. This dialogue occurred in Niagara county this year:

"You should cultivate your peach orchard better and get into it earlier."

"Yes, I know; but farm work was too pressing, and I couldn't," replied the owner.

"What part of your farm brings you the most money?" asked the visitor.

"Well," said the other, reflectively, "I guess it is the peach orchard."

"Then I should attend to the peach orchard first, and let the farm work go."

"Say, that's so! I hadn't thought of it in that way before," and the owner turned down a new leaf.

Methods of cultivating.—The best tillage is that which begins early in the season, and which keeps the surface stirred until midsummer or early fall, and the best implements are those which secure this result with the least amount of time and labor. For the first few years, it is generally advisable to turn the land rather deep with a plow at the first spring cultivation.

There are many styles of clod crushers, spring-tooth harrows, cut-aways, and smoothing harrows which will adapt themselves readilyto the cultivation of the particular soil in question. In all friable or loose soils, shallow cultivation is always preferable, and in these some form of cut-away or smoothing harrow will be found to be efficient. When the land is once in good condition, but little effort and time are required to run through the orchard. Crust should never be allowed to form upon the surface, and weeds should be killed before they become firmly established. The entire surface of the orchard should be stirred as often as once in ten days.

In general, level culture is best. This is secured by plowing one year to the trees and the following year away from them, one year north and south, and the next year east and west. It is somewhat difficult to plow away from large trees, however, and with the cultivators or harrows now in use, it is easy to work the soil away by subsequent cultivation, allowing the furrow to be thrown towards the tree each spring; but it always advisable, upon fairly level ground, to plow the orchard in opposite directions in alternate years.

The difficulty of working close to the trees has had the effect of encouraging too high pruning. There is a tendency to start tops too high rather than too low, thereby exposing great length of trunk to injuries of sun and wind, and elevating the top beyond the reach of pickers and of sprays. For most trees, the ideal length of trunk is under four feet rather than above it, and implements now in the market allow of this lower training. Trees which have low tops or which hang low with fruit can be reached by separating the halves of many of the double harrows by means of a long double-tree, so that the halves, when adjusted, run from four to six feet from each other. A cut-away harrow rigged in this way will work away the back-furrows from under the trees during the season. All cultivators or harrows with high handles, wheels or levers, should be discarded if orchards are worked when the limbs bend low with fruit.

This labor of working about trees is greatly facilitated by the use of harnesses which have no metal projections. There should be no hames with elevated tops, and the turrets on the back-pads should be simply leather loops. The back-pad itself should be reduced to a single wide strap entirely devoid of wadding. Harnesses of the Sherwood type, with no traces, but drawing by a single chain between the horses, are excellent in orchards, as they require no whiffletrees. Such harness is shown in the cover illustration.

It will now be asked what crops may be grown in the orchard. Grain and hay, never! Any hoed crops may be used for the first few years; but it must be remembered that every crop competes with the trees for food and moisture, and whatever may befall the crop, the trees should not be allowed to suffer. An open space should be left about the tree, free of crops, at least several feet in extent. In fact, this space should correspond with the spread of roots of the tree. Corn and some other plants will appropriate moisture more quickly than the tree can. In orchards set less than twenty feet apart, the land should rarely be cropped after the third year; but apple orchards, if well cared for, may be cropped lightly for seven or eight years. In no case should the grower expect to secure as much crop upon orchard land as upon other areas; and the drier the land, the less should it be cropped. When the orchard comes into bearing age, give it the entire land. Thereafter, the most profitable crop to raise between the trees is cultivators!

The growing of nursery stock in orchards—a frequent practice in Western New York—should be discouraged. This crop makes essentially the same demands upon the land as the orchard itself, and it does not allow of those variations in cultivation and management which may be essential to the varying seasons. It may be true that enough fertilizer can be placed upon the land to replace the loss of plant-food, but it is rarely done. And, more than this, the nursery stock drinks up the moisture which should be used by the orchard. Nursery stock is known to be particularly hard upon land, so much so that nurserymen never grow two crops of fruit-tree stocks in succession upon the same area.

Sod may sometimes be allowed in an orchard if it is closely pastured, but hay should never be cut. Sod lands are not only drier than cultivated ground, but they are favorite breeding places of insects. Borers are particularly bad in grass land. No stone fruits should ever be allowed to stand in sod, and the same may be said of dwarf pears. Apples and standard pears may now and then be seeded with safety, but it is certainly true that, in general, fruit decreases in proportion as sod increases. Very thrifty young apple and pear orchards may sometimes be thrown into bearing by seeding them down for a time, but the sod should be broken up before the trees become checked in vigor. The use of clover and other temporary cover crops as a means of fertilizing the land, is discussed farther on.

Most of the apple orchards in New York are in sod, and growers are always asking if they shall be plowed up. If the growers of apples are satisfied with the crops of the past few years, let the orchards alone; but if it is thought that better crops are desirable, do not hesitate to make an effort to obtain them. It is surprising that the disastrous failures of recent years have not awakened farmers to the necessity of really doing something for their orchards. Now and then an enterprising man makes an energetic attempt and is rewarded, but the greater number continue to exercise the most thorough-going neglect and to bewail the failure of the crop. Yes, plow the old apple orchard; then fertilize and spray it. Or, if the roots are too near the surface to allow of plowing, harrow it thoroughly when the turf is soft in spring, and continue to work it during the season. If this is not feasible, then pasture it closely with sheep or hogs, feeding the stock at the same time. If this cannot be done, and the orchard is unprofitable, cut it down.

Fertilizers.—Nitrogen, potassium and phosphorus are the elements which need to be applied to orchard lands.

Nitrogen is particularly efficacious in promoting growth. In fact, the amount of growth and the color of the foliage are fairly reliable guides for the application of nitrogen. When mature or bearing trees make a foot or more of growth upon all shoots, and when the leaves are of good size and dark color, the orchard probably has enough nitrogen. A heavy application of nitrogen to such orchards might do more harm than good, in promoting growth at the expense of fruit, or, in the case of some stone fruits, in producing a poorly matured growth which will be likely to suffer in winter. Orchards are grown for fruit not for forestry purposes. In general, it is better to supply nitrogen by good tillage —which assists nitrification—and an occasional green-manure crop, than by the application of nitrogenous fertilizers. If the orchard is not growing and is yellowish in foliage, good cultivation—begun early and repeated very frequently—in connection with the use of potash, phosphoric acid and green manures, will commonly correct it. It is probable that lack of moisture is quite as much the cause of the weakness as lack of nitrogen, particularly if the orchard has been in sod. Now and then a tree will be found which fails to respond to ordinary treatment. If the tree is healthy—that is, not attacked by disease or borers—it may sometimes be brought into a vigorous condition by applying to it a light dressing of nitrate of soda; but this treatment need seldom be applied to an entire orchard. (Consult Bull. 153).

In orchards which are thoroughly tilled, the use of barn manures should generally be discouraged, unless the land is lacking in humus. This advice is particularly applicable to vineyards, and all other fruits which run very strongly to wood. It is better economy to apply barn manures to the annual crops of the farm. The old neglected apple orchards of the country, however, may receive barn manures with safety; yet, even here it is a question if economy would not dictate tillage and late green manures to supply the nitrogen, except perhaps for a season or two when an attempt is making to rejuvenate an orchard. Mulching a sod orchard with manure often gives fairly good results in cases in which the land cannot be tilled, but better results in the way of fertilizing and in freedom from weeds and insects can be obtained by pasturing closely with sheep or swine.

Potash is probably the most important element to be applied directly to orchards, particularly after the trees have reached bearing age. The store of available potash in the soil is much increased by the thorough tillage which has already been recommended, but in bearing orchards it should also be supplied every year in some commercial form. One of the best sources of potash for orchards is wood ashes, but this material is so often weakened by leaching that it cannot be confidently recommended. A good sample of unleached hard wood ashes should contain from 6 to 9 per cent. of potash, but much of the commercial article does not analyze above 2 to 3 per cent. Potash in this form has a trade value of 4½ cents per pound. To this value of wood ashes should also be added 2 per cent. or less of phosphoric acid, now worth 6 cents a pound; it also is of value in sweetening sour soils. Forty to fifty bushels to the acre is considered to be a good dressing of wood ashes, if it has been kept dry.

Muriate of potash is perhaps the best and most reliable form in which to secure potash at the present time. Commercial samples generally contain from 80 to 85 per cent. of muriate of potash, or about 50 per cent. of actual potash. Kainit or German potash salts is an impure muriate of potash containing about 12 per cent. of potash. An apple orchard in full bearing and upon loose soil may receive as high as 1000 lbs. of muriate of potash per acre, but a normal and economical application is from 200 to 500 lbs. Sulfate of potash is also thought to be a good form in which to buy potash. The commercial article will analyze 50 per cent. or less of actual potash. Sylvinite is sometimes bought by farmers as sulfate of potash. Its potash is in the form of both muriate and sulfate. Its value—like that of other materials mentioned—should be reckoned upon the amount of potash present.

Phosphoric acid may be obtained in the form of a high grade plain superphosphate (dissolved South Carolina rock), in bone compounds, and Thomas slag. The plain superphosphate contains about 16 or 18 per cent. of phosphoric acid, and 300 to 500 lbs. per acre is a liberal and very useful dressing for bearing orchards. The bone fertilizers are always valuable. Those which are untreated give up their phosphoric acid slowly unless they are very finely ground. Dissolved bone gives more immediate results. Thomas or basic slag, which is yet scarcely in the market in this country, has given good results in many tests, but it parts with its fertility very slowly. It is yet too early to recommend this material for orchards with full confidence.

In general, phosphoric acid is rather less important in fruit plantations than potash, although this order is reversed in general farming. Potash should undoubtedly be the leading factor in orchard fertilizers, and nitrogen, as I have said, may be obtained mostly by means of tillage and green crops. It will then be seen that the use of combined or "complete" commercial fertilizers may not be economical. The best results are to be expected when the fruit-grower observes closely the behavior of his trees and then applies such materials as they appear to need. Any of the materials mentioned in the foregoing remarks may be mixed together, so that the phosphorus and protassium can be applied at the same sowing. However, heavy applications of any one or two of the fertilizing elements causes heavier demands to be made upon the remaining element in the soil and thereby tends to exhaust it.

Cover-crops and green-manuring.—A sowed crop in the orchard may be valuable in two ways: by affording a cover to the land, and by improving the soil when it is plowed in. As a cover, it may keep down weeds, protect the land, and hold the rainfall. As a green manure, it may add fibre to the soil and thus augment its power of holding fertility and moisture, and it may add directly to the fertility of the land. This late crop catches and holds leaching nitrates, which the tree-roots utilize earlier in the season.

As a rule, crops grown for cover alone should be sown not earlier than midsummer. The most thorough tillage can then be given early in the season, and the benefits of the cover can be secured for the early fall and winter. It is generally advisable to grow a crop which answers for both a cover and green manure, although it is easily possible to make the soil too nitrogenous for some fruits by the extravagant use of such fertilizers.

There is much confusion in the popular mind concerning the relation of cover-crops to moisture. Some contend that any crop which shades the ground, will keep the surface moist and conserve moisture, whilst others, knowing that all plants exhale water, consider that any crop tends to make the land dry. Both these opinions are partly correct. A crop which occupies the soil the entire season and which does not allow of cultivation will make the land dry, whilst one sowed late in the season upon land which has been thoroughly tilled during May, June and July, will not seriously rob the soil of moisture. At all events, there need be no fear of drying out the soil by sowing a late crop, for the serious injury of drought is usually effected before such crops are established; and the tree needs to be checked, rather than stimulated, at this season. Trees which are carrying a heavy crop may need to be tilled until the crop is nearly mature. The most marked way in which such crops conserve moisture is by means of the fibre and humus which they impart to the soil when plowed under; but even this humus cannot compete with cultivation as a retainer of moisture.

An experiment now continuing in one of our orchards illustrates the value of cultivation over green-manuring alone, in this dry year. The orchard is a hard clay,—just the soil which is benefitted by the loosening effects of green-manures. The orchard was divided into three parts in 1890, a year after the trees were set. One-third has received liberal annual dressings of commercial fertilixers,* and has been well tilled; another third has had no treatment except good tillage; and the remaining third has had liberal applications of potash and has then been sown early to a nitrogenous (leguminous) green crop. This third part nas simply been plowed and fitted well each spring, and then sown, having received no subsequent tillage. The crops were all plowed under the following spring. The following are the crops:

1890. Mixed beans. Sowed June 16.
1891. Field peas. Sowed June 24.
1892. Vetch. Sowed June 16.
1893. Cow peas. Sowed June 19.
1894. Field peas. Sowed June 14.

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* This experiment has not yet progressed far enough for report upon methods of fertilizing, and is mentioned here only for the purpose of contrasting methods of cultivation.

Here, then, is a chance to compare the effects of tillage with humus in a season of almost unprecedented drought. At this writing (Sept. 1, 1894) the green-manured strip is much the dryest part of the orchard. The tree growth in this part is much less vigorous and the leaves perceptibly lighter colored than on the adjacent plots. Even the unfertilized but well tilled tract shows a better foliage. In this green-manure part, leaves on peach trees are now beginning to yellow and fall from the effects of drought, whilst the same rows, when they strike the other plots, show perfect foliage. In apricots the effects are also marked. Pears and plums also show the differences. In the cultivated part one can easily stir up loose earth with the toe of his boot, while in the green-manured part one has to dig from six to ten inches in a hard soil before he can find visible moisture. Careful tests show the same fact. Samples of soil were taken to the depth of 1 foot on September 1, by means of a soil sampler, eight samples being lifted from representative parts of both the tilled and untilled areas. Four of these samples were combined into one, and this mixture constituted the complete sample which was used in a test for moisture ; that is, there were two samples of untilled soil and two of tilled soil, but each of these was made up of four other samples selected from various parts of the areas. These samples were carefully weighed and were then equally fire-dried and weighed again. The loss in weight represents the comparative content of free water in the different samples. The results are as follows:

	Sample I.	Sample II.
Moisture in tilled soil,	11.3	12.7
Moisture in untilled soil,	8.7	9.6

In addition to this difference in moisture between the two areas, it should be said that in the tilled land it was distributed to within two inches or less of the surface, while in the untilled land the first few inches was exceedingly dry. In other words, in the tilled land nearly the entire soil was in condition to part with its fertility, while in the other the uppermost and richest soil was inactive.

All this emphasizes the fact that tillage alone is better than green-manuring alone. But the best results would no doubt have been obtained if good tillage had been given for two or three months, and if the green-crop had been sown in August or September. In general, I believe this combination to be an excellent one for orchards, particularly for such lands as lack nitrogen and vegetable matter, and for those fruits which, like peaches, are benefitted by some winter protection of the soil. Walter F. Taber, of Poughkeepsie, one of the most careful horticulturists in the state, gives me this bit of experience under date of August 30, which is suggestive in this connection ; "Dry is no name for it here, but my place does not show it like many others. I have two fields which show how moisture can be held in the soil. One is a strawberry setting of one and one-fourth acres, made upon a heavy growth of rye plowed under April 26 and 27, and the ground worked fine and rolled May 10, and set the 11th and 12th. The other is one and seven-eighth acres of sweet corn. This piece was seeded with clover and turnips last August and September, and the whole growth of both clover and turnips was plowed under May 15 and 16, and the land was planted to sweet corn May 29 and 30, after receiving a dressing in alternate strips of Compound Corn Manure and muriate of potash. Both these pieces are upon black soil which has burned up in former years with a less severe drought than at present ; but now my black soil is doing best." Our own orchards have withstood the drought wherever well tilled ; and the same is true wherever I have been in Western New York. But the neglected orchards are suffering.

It will now be asked what is the best plant for cover and green manure. It is hard to tell. Clover is the stand by, but it is generally difficult to obtain a good "catch" late in the season, and it should stand on the land an entire season in order to obtain its full value. Upon good and well-tilled lands and in favorable seasons, considerable herbage can be obtained for turning under in the spring if it is sown the preceding August or September ; but in general it is unreliable as an annual crop.

Vetch answers the purpose admirably in many respects, as shown in our bulletins 49 and 61, and I think that it is one of the best all-around cover-crops yet proved in New York State. It is killed by the winter, however, and it therefore takes no advantage of the early days of spring. But this fact is in its favor for some occasions, because it encourages very early plowing. It must also be sown too early in the season for best results with tillage. It should be sown not later than the middle or last of July in this latitude. It affords an excellent winter cover for the soil, and it is rich in fertilizer value. It should be sown at the rate of a bushel of seed to the acre. Seed can be obtained of the leading seedsmen.

Rye is a favorite cover-crop in peach orchards, chiefly because it grows well upon light soils and can be depended upon to make good growth with the most indifferent preparation of land; and it can be sown very late. It contains very little fertillzing value, however.

Cow peas, as shown in Bulletin 61, are killed by the first frost and must therefore be sown very early if growth of any consequence is obtained. The leaves also fall when the plant is frosted, and the land does not receive so much protection as it does from other plants.

Common field beans are open to much the same objection as the cow pea, although the season of growth is shorter. We used them in 1890 on a part of one of our orchards, but concluded that they were unprofitable as a cover-crop.

Field peas are excellent for fall sowing in orchards. Last year a sowing of peas made on August 18, made vines two to three feet long and completely covered the ground.

The crimson clover is the ideal orchard cover and green-manure, although it will not always endure our winter. We made a sowing of it late in the summer of 1893. The "catch" was very poor, but what plants we obtained endured the winter and grew vigorously this spring. In New Jersey, as stated in Bulletin 100 of the Experiment Station of that state, the following points, amongst others, are now considered to be established:

"Crimson clover is an annual plant, hardy for the whole state; it has been successfully grown in every county from Cape May to Sussex. It is adapted for a wide variety of conditions, both in reference to character of soil, and method and time of seeding, though not as a substitute for red clover."

"Crimson clover may be seeded in orchards, berry patches, corn, tomatoes, etc., and upon raw ground following after potatoes, tomatoes, melons or other crops harvested before September. It is not adapted for seeding with wheat or rye."

"The amount of seed may range within wide limits—8 to 16 pounds per acre; larger amounts are usually required when sown with other crops, and smaller amounts when sown upon raw ground or in orchards. Twelve pounds per acre will doubtless be found to be sufficient."

"No failures to stand the winter have been reported when good, American-grown seed was used. It is more hardy than red clover. Foreign seed has not proved satisfactory. It contains as impurities weed seed and less hardy varieties of this clover. The seed is not as yet produced in any considerable quantity in this state. That used in our experiments was raised in Delaware, where the business of seed-growing is assuming considerable proportions and is reported to be profitable."

"Regarded as a green manure, particularly as furnishing nitrogen derived from the air, this crop possesses many advantages due to its time of growth and development."

"Good crops of this clover can be obtained on naturally poor or worn-out lands when fertilized with the mineral constituents only; these soils are rapidly improved by the addition of the nitrogen and accompanying organic matter contained in the crop."

"This plant provides a good pasture before other crops are available. An early pasture is not only valuable for the food contained in it, but also because it helps to insure proper feeding and to prevent too early use of other and later pastures. It was pastured this year in central New Jersey as early as April 10th. The crop when six inches high contained over 1,300 pounds of digestible food per acre, sufficient to properly nourish twelve cows for one week."

"The fertilizing value per acre of the residue in the roots, is equivalent in nitrogen and organic matter to that contained in three tons of city manure."

In Chautauqua County, crimson clover was sown last year by G. Schoenfeld, of Westfield, whose success with it has led to a general trial of the plant in that vicinity. Mr. Schoenfeld gives this account of his experiment:*

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* Grape Belt, Aug. 3, 1894.

"A year ago last June I procured a bushel of American grown seed, which I sowed the 22d and 23d of August in different spots in the vineyard, at the rate of 20 pounds to the acre. A vineyard of one and one-half acres, heavy brick-clay, was sown entirely. On account of the protracted drought at the time, it was three weeks before it came up and it was what is called a poor stand, and I was also disappointed that it did not make a better growth before winter set in. But it wintered well, which settled the only point that I was in the least doubtful on,—if it can be grown in Chautauqua county—and on which point I was unable to get any information. The lack of growth in the fall was made up the following spring, and on the 10th of May the plants averaged 15 inches in height and were in full bloom. The first week in June the crop was turned over with a Rochester gangplow."

D. R. Pease, Trumansburg, Seneca County, has also had experience with crimson clover. He writes me as follows: "I sowed a small piece August 25, 1893. It made some growth in the fall and went through the winter in good condition. It began to grow as soon as the frost was out of the ground last spring, and by May 1st it was a heavy crop. I allowed it to ripen and saved the seed, which I sowed September 1, 1894. I am well pleased with it, and think that it will prove valuable as a mulch."

ABRIDGEMENT.

If orchards are to be made profitable, they must receive as good care as other crops.

Good drainage, natural or artificial, is essential to success. Trees are impatient of wet feet.

Well drained lands are drier in wet spells and moister in dry spells than other lands. They can be worked earlier in spring.

Good tillage increases the available food supply of the soil and also conserves moisture.

Trees should be made to send their roots deep into the soil, in order to fortify themselves against drought. This is done by draining the soil and by plowing the orchard rather deep at first.

This deep plowing should begin the very year the trees are set and it should be continued every spring until the habit of the trees is established,—say two to four years.

Moisture is retained in the upper soil by very frequent but shallow tillage, by means of which the surface soil becomes a mulch for the soil beneath.

Tillage should be begun as soon as the ground is dry enough in spring.

This tillage should be repeated as often as once in ten days or two weeks throughout the growing season, whibh extends from spring until July or August.

Tillage should not exist for the purpose of killing weeds. Weeds have taught the most important lesson in agriculture, to be sure, but the schoolmaster should now be able to retire.

Late cultivation may be injurious by inducing a late growth. At all events it can be of small utility when the tree begins to mature and rain becomes frequent. This season of respite gives the grower the opportunity of raising a green-manure, and of adding fertility to his land at trifling expense and with no harm to his trees.

Fall plowing may be advisable for farm crops, but it should generally be discouraged in orchards. The land in orchards should usually be left compact in the fall, and it is advisable to cover it with some close herbage.

Only cultivated crops should be allowed in orchards early in the season. Grain and hay should never be grown.

Nursery stock should not be grown in orchards.

Even hoed or cultivated crops may rob the trees of moisture and fertility if they are allowed to stand above the tree roots.

Cultivators is the best crop to raise in an orchard.

Sod is sometimes allowable in apple and standard pear orchards, but never in other fruit plantations; but even then it should generally be pastured closely with sheep or hogs. If the stock is fed at the same time, the land will fare better.

Watch a sod orchard. It will begin to fail before you know it.

Probably nine-tenths of the apple orchards of New York state are in sod, and many of them are meadows. Of course they are failing.

The remedy for these apple failures is to cut down many of the orchards. For the remainder, the treatment is cultivation, fertilizing spraying—the trinity of orthodox apple-growing.

In general, level culture is best. The modern cultivators and harrows make such cultivation easy.

Trees, especially apples, are often trained too high, because of the difficulty of working close to them. Modern tools will bring the heads within reach.

Harnesses with no projecting hames nor metal turrets should be used in bearing orchards. Those requiring no whiffletrees are also useful.

Potash may be had in wood ashes, and muriate of potash. It is most commonly used in the latter form. An annual application of potash should be made upon bearing orchards. Of the muriate, from 200 to 500 pounds may be used to the acre in mature orchards.

Phosphoric acid is the second important fertilizer to be applied artificially to orchards. It may be got as plain high-grade superphosphate (dissolved South Carolina rock), in the bone fertilizers, and perhaps in Thomas slag. Of the plain superphosphates, from 300 to 500 lbs. may be applied to the acre.

Nitrogen can be obtained cheapest by means of thorough tillage (to promote nitrification) and nitrogenous green-manures. There is rarely occasion for buying it for fruit plantations, if the lands are properly tilled and cropped.

Nitrogen promotes growth. It should therefore be used with some caution, for orchard trees should be grown for fruit rather than for timber. Yet, an occasional application of nitrate of soda may be very helpful.

Barn manures are generally more economically used when applied to farm crops than when applied to orchards; yet they can be used with good results, particularly when rejuvenating old orchards.

In general, the commercial complete fertilizers are less rational for orchards than a fertilizer made for the occasion from materials evidently needed by the trees; but the complete fertilizers give much better results than the prevailing indifference and neglect.

Cultivation may be stopped late in the season, and a crop can then be sown upon the land. This crop may serve as a cover or protection to the soil and as a green-manure.

A green-manure improves the soil by adding fibre to it and by increasing its fertility. It catches the nitrates which, earlier in the season, are used by the tree-roots. Vegetable mold in the soil increases its power of holding both moisture and plant-food.

The crops well adapted to this late sowing are few. Vetch is one of the best which has been well tested in the State. But everything points to crimson clover as the ideal orchard cover and green-manure.

The gist of it all is that orchards should be cultivated and fed. Cultivation should begin early and be repeated often. It may be stopped in July or August if the grower thinks best, and then, if the land needs it, a green-crop may be sown for turning under the next spring. L. H. BAILEY.

NOTE —Other bulletins from this Station bearing upon the general subject of management of fruit lands are :

69. Hints on the Planting of Orchards.
102. General Observations Respecting the Care of Fruit Trees.
103. Soil Depletion in Respect to the Care of Fruit Trees.
117. Fruit Brevities. Contains an article on Crimson Clover.
153. Impressions of our Fruit-Growing Industries.

Bulletin 73. **September, 1894.**
Cornell University Agricultural Experiment Station.
BOTANICAL DIVISION.

LEAF CURL AND PLUM POCKETS.

CONTRIBUTION TO THE KNOWLEDGE OF THE PRUNICOLOUS EXOASCEÆ OF THE UNITED STATES.

By GEO. F. ATKINSON.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.

LEAF CURL AND PLUM POCKETS.

CONTRIBUTION TO THE KNOWLEDGE OF THE PRUNICOLOUS EXOASCEÆ OF THE UNITED STATES.

The distortions of the leaves of the genus *Prunus* known popularly as leaf curl, and the hollow, spongy, abnormally enlarged fruits commonly called "plum pockets," or "plum bladders," are caused by certain fungi belonging to the family *Exoasceæ*. The *Exoasceæ* are composed largely of parasitic species which live upon many of the higher plants and are especially abundant upon the *Rosaceæ*. The family is characterized by the possession of fruit structures, termed asci, which are approximately cylindrical and stand, more or less crowded together, out upon the surface of the affected portions of their hosts.

Several attempts have been made to establish genera for what seemed to be natural divisions into which the members of the family grouped themselves. These genera were based principally upon the number of spores in the ascus. The known spore characters, however, in this family are so remarkably inconstant that nothing more than an unsatisfactory artificial classification has thus far been proposed upon that basis. Sadebeck* has recently proposed a more natural subdivision of the parasitic *Exoasceæ*. Those species in which the asci are not developed from a common subcuticular hymenium, but from the ends of intercellular hyphæ are made the ground for a new genus, *Magnusiella*. This genus is represented in the United States by the well known *M. potentillæ*† (Farl.) Sadeb., upon *Potentilla canadensis*. Those species in which the asci are developed from a common subcuticular hymenium are farther divided into two genera. Those with a perennial mycelium are placed in the Fuckelian genus *Exoascus*, while those lacking a perennial mycelium are placed in the Friesian genus *Taphrina*. *Taphrina* as thus emended contains species in which a new infection each year is brought about by spores. A common representative of the genus in this country is *T. coerulescens** (Mont. et Desm.) Tul. The species of *Exoascus* having a perennial mycelium, a new infection each year is secured by the mycelium which winters over in the tissues of the host, and by the spores.

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* Die parasitischen Exoasceen. Eine Monographie. Abgedruck. a. d. Jahrbuch d. Hamb. Wiss. Anstalten. x. 2. Hamburg, 1893.

† Exoascus deformans (Berk.) Fuckel var. potentillæ Farlow, Proceedings Amer. Acad. Arts and Sciences, XVIII, 1883, p. 84. Taphrina potentillæ Johanson, Oefvers. af. Kgl. Vet.-Akad Forh. 1885. Magnusiella potentillæ Sadeb. Abgedr. a. d. Jahrb. d. Hamb. Wiss. Anst. x. 2. 1893, p. 86.

The prunicolous species of *Exoasceæ* thus far known all belong to the genus *Exoascus*. These have for the present purpose the chief interest and farther discussion of the other two genera is not contemplated here.

Considerable material has accumulated during a period of observation extending over five years, which seemed to justify the preparation of the matter for publication. Especially does this seem to be the case since no comprehensive illustrated account of those species occurring on the stone fruits in the United States has as yet been attempted. The economic importance of the stone fruits suggested the appropriateness of presenting the contribution as a bulletin for the information of fruit growers, since a knowledge of the known characteristics and mode of perpetuation of the parasites will aid those interested in checking or preventing the injuries.

In making a critical examination of the material at hand it appeared that there were several well characterised undescribed species, a fact which was not anticipated at the outset. This is a sufficient explanation of the necessary use of much technical description in a portion of the paper.

No part of the plant is exempt from the attacks of these fungi except the roots. The first marked effects of their active presence in the tissues of the host is the stimulus to an increase in the number or size of the cells so that characteristic malformations of the diseased parts appear. In the leaves the increase in the number of the cells of the diseased portion causes that part of the leaf to arch upward or downward in a series of irregular folds, or a somewhat circular spot becomes strongly arched in one direction forming a deep, wide mouthed pocket. The twigs become enlarged in diameter and variously contorted, or an early development of the buds is stimulated producing what are commonly called "witches brooms." The fruit becomes transformed into a large spongy mass of tissue, which is hollow and devoid of the "stone" or "pit;" or only one side of the fruit is affected when irregular one sided swellings of similar tissue are developed. The floral envelopes in some species partake also of the hypertrophy, and in other cases only the superficial portion of the fruit is affected when the "stone" is normally developed. In the latter case sometimes a warted condition of the fruit appears. The young leaf buds of some species are transformed into a large spongy hollow mass, much resembling in texture the tissue of the "plum pockets." A number of these characteristic hypertrophied parts of various plant organs are illustrated in photographic reproductions in Plates I–X.

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* Ascomyces coerulescens Mont. et Desm. Ann. d. Sci. Nat. Bot. ser. 3, x. p. 345. Taphrina coerulescens Tulasne, Ann. d. Sci. Nat. Bot. ser. 5, v. p. 127.

Mycelium. In all of the species at present known on the genus *Prunus*, with one exception,* the mycelium penetrates to some depth in the tissues, but it is always intercellular. It is quite characteristic and can usually be readily differentiated from the mycelium of other fungi when examined in situ. It is very irregular in its course and the size of its cells. These are cylindrical, oblong, clavate, or oval, and are joined in an irregular chain without order between the cells of the host. The mycelium may be quite abundant in some species so that when the other intercellular substances and portions of the cell walls of the host are dissolved out by the use of chloral hydrate, and differentiated by the use of some of the stains like eosin, it presents a very intricate network of threads. In other species or in parts of the plant not so seriously affected, or in parts where the mycelium is passing the winter, it is more scanty, frequently consisting of isolated, oval or irregularly oblong cells.

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* **Exoascus minor Sadebeck, Kritische Untersuch. ü. d. durch Taphrina-Arten hervorgebr. Baumkrankheiten. Abgedruck. a. d. Jahrb. d. Hamb. Wiss. Anst. VIII, 1891, p. 24.**

Hymenium. From the interior of the tissues the mycelium grows to the surface and spreads, by branching, out over the epidermal cells just beneath the cuticle. The cells of the subcuticular layer soon become nearly isodiametric and are usually developed in such numbers that eventually they are closely crowded, when they become angular in outline. By a less profuse development they may appear as variously branched chains of oval cells. These subcuticular cells are very rich in protoplasm, much more so than the cells within the tissue. They make up what is called the hymenium. In figure 81 is shown a section of a portion of a deformed bud of *Prunus angustifolia* presenting the intercellular-mycelium and young hymenium of *Exoascus mirabilis* Atkinson. In fig. 83 is represented a surface view of a portion of the hymenium of the same species.

Each of the cells of the hymenium elongates perpendicularly to the surface, forming cylindrical or clavate cells which divide by a septum into two cells, the septum usually being near the base. The inner cell is the stalk cell while the outer cell is the ascus or fruiting cell. In each ascus there are developed a variable number of spores, usually four or eight. These are rounded, oval, or elliptical in form, and are colorless. At normal maturity a perforation usually occurs at the apex of the ascus and the spores are ejected with considerable force. The ascus becomes turgescent by endosmosis, this produces a pressure upon the walls and a rupture occurs at the weakest point, which is at the apex. De Bary* says that the ejection of the spores takes place in a manner exactly similar to that in various species of other Discomycetes which he examined. I have several times watched under the microscope the expulsion of the spores of some of the Discomycetes like *Dasyscypha virginea* (Batsch) Fuckel, *Propolis faginea* (Schrad.) Karst. *Trichopeziza capitata* (Peck) Sacc., and others. In the Pyrenomycetes I have watched the same phenomenon in the case of *Spherella pyri* Auersw. By mounting specimens which are not too old in fresh water and immediately noting the asci under the microscope they can be seen to become turgescent and finally a rupture occurs at the apex and the spores are shot out suddenly. Usually the spores are all shot out together from a single ascus. De Bary[*] and Rathay[†] both placed freshly gathered specimens of *Exoascus* on a glass slip in a moist atmosphere and after several hours the glass was covered a distance of 1 cm. from the specimen with the spores, which formed a white ring around it.

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* Exoascus pruni und die Taschen oder Narren der Pflaumenbäume, Beiträge z. Morph. u. Phys. d. Pilze, Erst. Reihe. Abgedruck. a. d. Abhandl. d. Senkenb. Naturf. Gesellsch, Bd. V, pp. 183 and 184, Frankfurt, 1886.

When the fungus is mature the affected parts of the plant present a whitish or mealy aspect caused by the numbers of asci and free spores.

Each spore in water or in nutrient solutions is capable of producing, by a process of budding similar to that of the yeast plant, smaller and similar cells. In water the parent spore becomes by this process smaller also. This frequently takes place within the ascus when the spores are not expelled at maturity, so that after a while the ascus is quite well filled with these small conidia. DeBary,[‡] Brefeld[§] and Sadebeck[||] record the results of attempts to grow the spores in artificial media. In no case was a mycelium observed to develop, but budding always took place where any growth appeared. By placing spores on the young leaf buds, or better on the leaves of seedlings, Sadebeck[¶] succeeded in observing the entrance of a mycelium in the leaves of *Alnus*. The species experimented with was *Exoascus tosquinetii* (Westend) Sadeb. The mycelium was observed to enter through the stomata into the tissues.

We can now enter into a more detailed discussion of the hypertrophied organs of the various species of *Prunus*, and the morphology and structure of the infecting species of *Exoasceæ*.

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[*] Ibid.

[†] Ueber die Hexenbesen der Kirschbäume, und Exoascus wiesneri n. sp. Sitzungsb. d. Math.-Naturw. Classe d. k. Akad. d. Wiss. Bd. LXXXIII, Abth. I, p. 280, Wien, 1881.

[‡] Exoascus pruni etc. Beiträge z. Morph. u. Phys. d. Pilze, Erst. Reihe, Abgd. a. d. Senkenb. Naturf. Ges. Bd. V. pp. 185, 186; 1886.

[§] Unters. a. d. Gesammtgeb. d. Mykol. Heft IX, pp. 142, 144, Münster, 1891.

[||] Die parasitischen Exoasceen. Abgdruck. a. d. Jahrb. d. Hamb. Wiss. Anst. X, 2 p. 13; 1893.

[¶] Unters. ü. d. Pilzgattung Exoascus und die durch dieselbe um Hamburg hervorgerufen Baumkrankheiten. Abgedruck. a. d. Jahrb. d. Wiss. Anst. p. 102; 1883. Hamburg.

Die parasitischen Exoasceen. Ibid. X, 2, p. 13; 1893.

PRUNUS PERSICA (L). Peach.

Exoascus deformans (Berk.) Fuckel.

The leaves and twigs are the only portions of the peach tree which are at present known to be affected with the fungus. The leaves are more commonly the place for the injury to be shown, and the twigs are but rarely attacked seriously or so as to attract attention. During June, 1894, I observed a tree on the Cornell University Campus having the leaf "curl" and a few of the ends of certain twigs were abnormally enlarged, though but slightly. One of these is reproduced from a photograph in Plate I, Fig. 1. The petioles of the leaf are also hypertrophied and profusely corrugated. From the petioles the hypertrophy can be seen to extend part way on the stem. Scribner* notes quite a serious injury to young shoots of nursery trees received from New York and transplanted at Knoxville, Tenn. The shoots for several inches below the leaf bud were considerably enlarged and presented a very much roughened or corrugated surface.

The disease in the leaves produces the distortions which are commonly spoken of as "leaf curl." With the increase in the number and size of the cells of the affected part the leaf is thrown into a series of irregular folds frequently transversely to the long axis of the leaf. Sometimes the arching of the leaf takes place more strongly on one side than on the other when a strong convexity appears on that side. When a large portion of the leaf is thus affected it frequently bulges out on one side along the middle and the edges of the leaf are drawn toward each other, the leaf appearing as if strongly inflated. In the affected portions of the leaf the green color pales and the parts are more or less brightly colored with reddish or yellowish tints. The leaf tissue at these parts is also thickened and assumes a "cartilaginous" consistence. The parenchyma cells are frequently very much elongated and curved or sinuous in form. The mycelium is perennial in the leaf buds, that is, it passes the late summer, autumn and winter months in the tissue of the leaf buds and in the following spring grows out with the developing leaf, multiplying more abundantly in certain portions than in others at times. This accounts for the fact that the whole area of the leaf is not at all times affected.

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*Fungus diseases of the grape and other plants, p. 126. 1890.

The persistence of the mycelium during the autumn and winter seasons in the leaf buds is probably the chief cause of the spread of the disease. When buds are taken for "budding" young seedlings in the nursery, if they are taken from an affected tree the disease is quite sure to be transmitted to every young tree which is started from a bud which contains the perennial mycelium. Since all of the affected leaves fall off from diseased trees at quite an early period, and at the time of budding the seedlings in August there is probably no sign of the curl in any of the leaves, it would be impossible to discriminate between the diseased and healthy trees, or the affected and free branches. An early selection of healthy trees for budding purposes would prevent the transmission of the disease through nursery stock.

Some experiments have been made in various places by spraying the trees with the Bordeaux mixture for the prevention of the leaf curl of peach trees. Some of the experimenters regard it as certain that the disease can to some extent be checked by this method. It is quite likely that, in some cases at least, another disease is confused with the leaf curl, and this fact might account in those instances for the results claimed. More definite experiments with an accurate determination of the diseases present should be made before too much can be claimed for the efficacy of the application of sprays for the prevention of this trouble.

The asci are developed on both surfaces of the leaf. Before the young asci pierce through the cuticle in their development they frequently raise the cuticle somewhat when it appears on drying as a thin whitish glistening membrane. The asci are nearly cylindrical, sometimes slightly clavate, and rounded or truncate at the free ends. They measure 25*–40 long by 8–11 in diameter, the larger number possessing intermediate measurements and being 30–35 by 9–10. The stalk cells are 6–8 high and 6–9 or 10 in diameter. They frequently taper considerably toward the base and often are quite sharp pointed. Occasionally where they are not much crowded the stalk cell is considerably broader, attaining a diameter quite equal to that of the ascus at its distal end, while it will be broader than the lower end of the ascus. The pointed ends of the stalk cells frequently intrude somewhat between the cells of the epidermis.

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* Measurements where not otherwise stated are given in terms of the micromillimeter.

The number of spores in an ascus is usually eight or approximately that number. They are rounded or oval and measure 3–4 in diameter. Sometimes the number is quite constantly four in a large number of asci and then the diameter is considerably greater, reaching 5 or 6. Asci with only four spores were found by me quite frequently on specimens of peach leaves distributed in Seymour and Earle's Economic Fungi, Fasc. I No. 14, and collected in Temple, N. H., June 18, 1888. A few of these are illustrated in fig. 21. Sadebeck* records the same variation in the case of *Exoascus epiphyllus*, *E. farlowii*, *Taphrina ulmi*, *T. bullata*, and others. Brefeld† suggested that according to the custom of some authors in using the number of spores as a basis for the separation of genera that the four spored *Exoasceæ* should be separated from the eight spored ones. Eight spored asci, however, present very great variations in a number of Ascomycetes so that in asci from the same perithecium there may be four, six or eight spored asci. Several species of *Teichospora* may be cited as examples of this.

PRUNUS AVIUM L. English Cherry.

Exoacus cerasi (Fuckel) Sadeb.

This species, *Exoacus cerasi* (Fuckel) Sadeb. has been found on "escaped cherry trees" at Germantown, Pa., by Prof. Thomas Meehan. It was distributed in Ellis, N.A.F. No. 2286, as *Exoascus wiesneri* Rathay.

This fungus forms the well known "witches brooms" of *Prunus avium* and *P. cerasus* in Europe. The mycelium is perennial in the affected twigs, the fructification only showing upon the leaves. In response to an inquiry Professor Meehan writes that the twigs are not deformed, but instead of forming spurs, or flower buds, as in ordinary branches, twigs are produced and this gives the broomy appearance. The presence of the mycelium thus stimulates an early and profuse development of twigs so close together that it roughly stimulates a broom. The asci in the specimens which I have seen occur on the under side of the leaf, though Robinson* says they occur on both surfaces. The leaf is deformed, presenting a series of folds and wrinkles, and the fructification shows as a dense whitish layer on the surface. The fungus was first described by Fuckel† as *Exoascus deformans* b, *cerasi*. Rathay‡ made a critical study of the perennial mycelium and the peculiarities of the infected branches, and named the fungus *Exoascus wiesneri*. It has been considered by many as only a form of *Exoascus deformans* (Berk.) Fuckel, and Robinson|| refers it to that species though he notes that the asci are much more slender than those of the typical form on the peach, the stalk cells proportionately much longer and they do not taper below as in that species. Sadebeck§ regards it as a distinct species but accepts the varietal name given it by Fuckel and writes it *Exoascus cerasi* (Fuckel) Sadeb. It appears to me that it is well distinct from the species on the peach.

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* Die parasitischen Exoasceen. Abgedruck. a. d. Jahrb. d. Hamburg. Wiss. Anst. X, 2, pp. 8–9. 1893.

† Unters. a. d. Gesammt. d. Mykol. IX, p. 144, Münster, 1891.

The asci are cylindrical and rounded or truncate at the free ends. According to Sadebeck¶ in the European specimens they measure 35–50 long by 7–10 in diameter. He remarks that there is great variability in the size of the asci. In the specimens from Germantown, Pa., which I have seen the asci measure 25–33, long by 6–9 in diameter. The stalk cells 10–17 high by 5–7 in diameter. The more common length for the asci is about 30. The spores are approximately eight in an ascus, and are round or oval. The details of the asci and spores are shown in fig. 25.

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*Notes on the genus Taphrina. Ann. Bot. I, p. 169, 1887-8.

†Symb. Mycol. p. 252, 1869.

‡Ueber die Hexenbesen der Kirschbäume und über Exoascus wiesneri, n. sp. Sitzungsb. d. Math. Naturw. Classe d. k. Akad. d. Wiss. Bd LXXXIII, Abth. I, p. 267, Wien, 1881.

||Notes on the genus Taphrina. Ann. Bot. I, p. 168–169, 1887–8.

§Kritische Unters. über die durch Taphrina-Arten hervorgebrachten Baumkrankheiten. Abgedruck. a. d. Jahrb. Hamb. Wiss Anst. VIII, p. 26, 1891.

¶Die parasitischen Exoasceen. Ibid, x, 2, p. 49, 1893.

PRUNUS PENNSYLVANICA L. Wild Red Cherry.

Exoascus insititiæ Sadeb.

I have referred to this species, specimens collected by Seymour at Temple, N. H., June 16, 1888, on the leaves of *Prunus pennsylvanica* L. It was distributed as *Taphrina deformans* (Berk.) Tul., in Seymour and Earle's Economic Fungi, No. 15. The specimen in the collection to which I have had access shows several small twigs curved to one side growing from the end of a larger twig. The specimen has very much the appearance of a small "witches broom." The young twigs are pale and slender, and the leaves are not much deformed, the upper surface being somewhat folded, while a large portion of the under surface is covered with the asci which give them a greyish white appearance. The mycelium is present in the inner tissue of the leaf but is not nearly so abundant as in the peach.

The asci are quite regularly smaller than those of *E. deformans* on the peach. Through the kindness of Mr. J. B. Ellis I have had the opportunity of seeing a specimen of this species on *P. domestica* from Sweden, and the asci are very much nearer those on that specimen than on the peach. In the measurements given by Sadebeck the asci are 25 long by 8–10 in diameter, which agrees quite well with the specimens on *P. pennsylvanica*, though on the latter some specimens measure 30 long, but the average is near 25. The stalk cells are 6–8 high by 7–9 in diameter and taper in many cases a little below, and then frequently intruding slightly between the cells of the epidermis. The measurements given for the stalk cells by Sadebeck are slightly larger, being 8 high by 8–10 in diameter. Aside from these slight variations it agrees very well with Sadebeck's species. It was first described by Sadebeck* from specimens on *Prunus insititia* and was later found by him on *Prunus domestica*. It forms "witches brooms" on both these trees in Europe.

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* Unters. ü. d. Pilzgattung Exoascus etc. Abgedruck. a. d. Jahrb. d. Hamb. Wiss. Anst. p. 113, 1884.

Kritische Unters. ü. d. durch Taphrina-Arten etc. Ibid, VIII, p. 27, 1891.

Die parasiten Exoasceen. Ibid, X, 2, p. 48, 1893.

PRUNUS DOMESTICA L. Plum.

Exoascus pruni Fuckel.

This fungus forms the well known "plum pockets," or "plum bladders" on the fruit *Prunus domestica*, the common cultivated plum. The mycelium is perennial in the fruit bearing branches and from these places grows out into the young ovaries in the spring. All or nearly all parts of the ovary are affected and the fungus stimulates the tissue of the ovary so that a remarkable hypertrophy occurs. The tissues become dry and spongy, the form of the plum being considerably enlarged. No stone is developed in the diseased plums and the interior is hollow and frequently traversed by loose threads of torn tissue. All of the plums on an affected tree are not usually affected, though I recollect seeing a tree in Chapel Hill, N. C., in the spring of 1886, on which there was not a single plum free from the disease. Frequently there are plums unaffected in the same cluster with the diseased ones.

The asci are very closely crowded together and frequently may develop quite irregularly, a few pushing through the cuticle first, followed later by others. A section of an affected fruit at this time would then show some asci very long and mature while others are not quite mature and the spores undifferentiated. There are many cells of the hymenium intermingled with the asci. The asci measure, in specimens which I have seen on *P. domestica* from Wisconsin, 30–60 long by 7–10 in diamter, and the stalk cells 15–22 high by 3–7 in diameter are rounded, or rarely pointed below. The longer asci are nearly cylindrical and many of the shorter ones slightly clavate. The spores are oval to elliptical, and from 3.5–5 in diameter. The measurements given by Sadebeck show a greater diameter, the ascus reaching a diameter as high as 15, and the stalk cell being given as 8 in diameter.

Robinson* speaks of a dimorphism in the asci, the slender ones being 43–60 long and 5.5–7 in diameter, while the stouter ones were 27–35 long by 9–12 in diameter. The size of the stalk cells he gives as 12–18 high by 5–8 in diameter. He also notes the fact that nearly all the asci which he examined were more slender in proportion to their length than those described by Sadebeck. I have seen specimens probably of this species on *Prunus domestica* in North, and South Carolina, but unfortunately did not preserve any of them.

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* Notes on the genus Taphrina. Ann. Bot. I, p. 166-7, 1887-8.

The shoots of *Prunus domestica* are sometimes deformed and enlarged bearing mature asci, the structure somewhat resembling that on the twigs of *Prunus angustifolia* Marshall. Prof. Halsted sent me some specimens collected at Manalapan, N. J. They are very old and overrun by some species of *Gloeosporium* so that it is not safe, it seems to me to attempt to decide what the species is. Some of the asci are illustrated in fig. 69.

PRUNUS SEROTINA Ehrhart. Black Wild Cherry.

Exoascus farlowii Sadebeck.

The ovaries of *Prunus serotina* are deformed by this species, the fruit becoming a spongy mass of tissue which is hollow within much as in the case of the fruit of *P. domestica* when affected by *E. pruni*. The ovaries are proportionately much more elongated, spindle shaped and curved, the end usually tapering to a long point. The floral envelopes are also hypertrophied and become persistent, which is not the case with *E. pruni* on the fruit of *P. domestica*.

The species was first described by Sadebeck* in 1890, from material collected by Dr. Farlow at Cambridge, Mass. In the material which Sadebeck examined he found the asci not crowded, but separated from each other, and this peculiarity, along with characters of the ascus and stalk cells, caused him to separate it from *E. pruni*, to which it had doubtfully been referred.† The distant asci, especially in the material examined by myself, does not seem to be a constant character, or even a frequent one, and I have examined quantities of material from Alabama, some from Canada, and some from Cambridge, collected by Dr. Farlow, and also by Halsted. The characters given by Sadebeck must then be modified so as to include the specimens with closely crowded asci. It is possible in specimens where the hymenium has not become evenly distributed over the surface that a section would show some asci which were considerably separated. But not taking this character into consideration I should consider it a distinct species from *E. pruni*. In 1889 I found a small quantity of this species in South Carolina, at Columbia. During the years 1890–93 I observed it as very common in Alabama, at Auburn. Quite large trees would have nearly all the fruit destroyed each year by it.

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* Kritische Unters. ü. d. durch Taphrina-Arten, etc. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. VIII, p. 30, 1891. See also Die parasiten Exoasceen, Ibid, X, 2, p. 47, 1893.

† Robinson, Notes on the genus Taphrina, Ann. Bot. I, p. 167, 1887-8 Ellis' N. A. F. No. 298. Here it is called E. pruni.

The asci are cylindrical and rounded or truncate at the free ends. They measure 20–33 long by 8–12 in diameter. The stalk cells are 12–20 high by 8–12 in diameter, averaging about one-third the length of the entire fruit body. These measurements give a greater diameter than that given by Sadebeck, 8–9 being the diameter given by him for the asci and stalk cells. The stalk cells frequently taper somewhat below and intrude themselves slightly between the cells of the epidermis at times. The mycelium I have not found to be so abundant in the tissues as is the case with *E. pruni* on *P. domestica*. The spores are more constantly rounded in form being approximately spherical, and are 3–4 in diameter. See figures 34–36.

Exoascus varius n. sp.

The leaves of *Prunus serotina* are frequently affected with a species of *Exoascus* which produces a folding or arching of the leaf. During the years 1890–3 I observed this to be very common and injurious on many trees in Alabama. In fact the same trees which were affected with the *E. farlowii* on the fruit had their leaves also badly affected. The shoots also were much deformed and sometimes enlarged, but there was not observed any tendency to the formation of "witches' brooms." Nor were any of the twigs observed to bear the asci. The deformity of the twigs or shoots occurred at the ends of the leafy branches, the leaves of the same being also diseased. Figures 13 and 14 are from photographs taken from living specimens. The deformity of the leaves and ends of the branches can be well seen. It is quite remarkable that the fruit of the same branches is also affected, and this is well shown in the same illustrations. Large trees, thirty and forty feet in height, presented a very interesting sight and were noticeable for a considerable distance on account of the defective foliage, and especially from the brown and dead colors which succeeded the dying of badly affected leaves. The two forms, the one on the fruit and the one on the leaves, were so common on the same trees and so closely associated that many times I have been strongly inclined to consider them one and the same species. This inclination has been strengthened by a study of the structure of the fungus, for in many cases the asci and stalk cells on the leaves are very much like those of *E. farlowii* on the fruit, as can be seen by a reference to figures 26–31. In fig. 26 the asci measure 20–27 long by 8–10 in diameter and the stalk cells are 12–17 high by 8–10 in diameter. These are the largest ones which I have noted and they come very near to typical ones of *E. farlowii* on the fruit. In fig. 27 the asci and stalk cells possess the same proportionate lengths, but the entire fruit body is shorter, while the width is the same. Specimens occur, however, in which the proportion between the length of the ascus and stalk cells is different and the stalk cell may be only one-fourth as long as the entire fruit body instead of one-third, and the relation of the form to that of *E. deformans* becomes more apparent. But at the same time the stalk cell preserves quite constantly the same or nearly the same diameter as the ascus, and in a larger number of cases it is much longer than that of the latter species. Specimens on the leaves from Smyrna, Del., communicated by Mr. J. B. Ellis, present much the same characters, and some of the variations are illustrated in figs. 30, 31. Specimens on the leaves from Temple, N. H., collected by Mr. A. B. Seymour, also agree in these characters, as shown by some of the asci illustrated in fig. 32. The spores are rounded and four to eight in an ascus.

A form similar to this I collected at Columbia, S. C., in the spring of 1889. A few leaves of a shoot which grew from the base of a large tree were affected. Unfortunately these specimens are now lost. On the same tree, but not near the affected leaves were a few of the fruits affected by *E. farlowii*. I should still be strongly of the opinion that the fungus on the leaves of *P. serotina* were but a leaf form of *E. farlowii* if it were not for the fact that I have observed two very different species of *Exoascus* growing in very close proximity to each other on the same tree, so close in fact that it is quite probable the mycelium of the two was intermingled in the branch which bore the affected fruits and leaves. These occur on *Prunus americana* under which paragraph the description of the species will be found. Another reason for considering them distinct species is the probable fact that usually a certain species quite constantly exercises a peculiar physiological influence upon the host, and that if the form on the leaves and twigs of *P. serotina* described here were the same species as that which occurs on the fruit of the same tree, we would expect it to produce a spongy abnormal growth in the buds and ends of the branches just as *Exoascus mirabilis* Atkinson does in the buds of *Prunus augustifolia*. For these reasons and from the fact that the fungus departs too widely from the characters of *Exoascus deformans*, it seems best to consider it as a distinct species, and I propose the name *E. varius* for it on account of the variable proportion which exists between the length of the ascus and stalk cell.

PRUNUS MARITIMA WANG. Beach Plum.

Exoascus communis Sadebeck.

This species affects the fruit of *P. maritima*, causing the plum "pockets." The specimens which I have seen were collected by Dr. Farlow at Dartmouth, Mass. Sadebeck* has recently described this species as occurring on this host as well as on *P. pumila* L. and *P. americana* Marshall, all from the United States. The structure of the asci and the relation of the stalk cells to the epidermis is represented in fig. 58. The asci are slender, rather slightly clavate, and rounded or somewhat truncate at the free ends. Sadebeck gives the measurements for the species as follows: The asci are 30–40 long and about 8 in diameter, the stalk cells 15 to 20 high by 3–5 in diameter. Although the stalk cells are often somewhat pointed below he says they do not intrude between the cells of the epidermis. The measurements I have taken from the asci on *P. maritima* vary but little from these dimensions, the asci being 25–45 long by 6–8 in diameter, and the stalk cells 15–25 long by 3–6 in diameter. They are somewhat pointed below and according to my observations do, to a slight extent, project between the cells of the epidermis, but not markedly so. The spores are rounded or oval in form and are 3–4 in diameter.

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*Die parasitischen Exoasceen. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. X, 2, p. 47, 1893.

PRUNUS NIGRA AITON. Wild Red Plum.

Exoascus communis Sadebeck.

Fruits of this plum distorted into the usual "pockets" or "bladders," collected by C. H. Davis, at Alma, Mich., June 2, 1894, were communicated to me by Prof. L. H. Bailey. The fungus agrees with Sadebeck's *E. communis.* The asci measure 35–45 long by 7–9 in diameter, and the stalk cells 15–22 high by 4–6 in diameter. The stalk cells are frequently pointed below and occasionally intrude slightly between the epidermal cells as in *E. communis* on *P. maritima.* The structure of the fungus and the relation of the stalk cells to the epidermis is represented in fig. 60.

PRUNUS PUMILA L. Dwarf cherry.

Exoascus communis Sadebeck.

Exoascus communis is also described by Sadebeck on the dwarf cherry, *Prunus pumila* L. Mature conditions of the fungus on this plum I have not seen. The plum "bladders" were formed on the fruit of this species on some plants which are growing in the Horticultural grounds of Cornell University, in June, 1894. A photograph showing the form of these "bladders" and the normal fruit is represented in fig. 19. The surface of the swollen fruits is quite uneven, and the tissue is characteristic of similar tissues in other species of plums thus affected. These specimens unfortunately did not mature their asci.

PRUNUS ANGUSTIFOLIA Marshall. Chickasaw plum.

Exoascus mirabilis n. sp.

This remarkable species deforms the leaf buds and young twigs of *Prunus angustifolia* Marshall, the Chickasaw plum (*P. chicasa* Michz.). It also occurs on related species of *Prunus.* I observed it in the vicinity of Columbia, S. C., in May, 1889, and during three years, 1890–92, I observed it as very abundant at Auburn, Ala., both on the wild *P. angustifolia* and its cultivated varieties. It produces in the young leaf buds and the ends of the young twigs an enlarged structure, the tissue of which is very much like that of the plum "bladders." The swollen bud or twig is usually whitish or yellowish white in color, the tissue is soft and spongy, and the structure is hollow at the center. They vary greatly in form, being clavate, oval, lanceolate, or elliptical; while the surface varies also to an equal extent, depending upon the stage of development of the bud or twig at the time that the growth is arrested. The bud may be brought well under contribution before the leaves have begun to open, when the large mass of tissue will present no appearance of even the leaf tips. Sometimes the leaves partly separate and then short or long points which are of the same kind of tissue will project from the bulk of the mass. Again, the leaves may be more or less expanded, so that some of them present green normal tips projecting from the swollen bud, and from this the green expanded portion varies through different specimens so that in some there are normal leaves standing out from it. Two of these conditions are reproduced from photographs of fresh specimens in figures 10 and 11, Plate V.

The asci are developed all over the surface of the spongy portion of the structure, and give it a mealy appearance. The twig is sometimes enlarged and deformed to some distance below the enlarged spongy end, and it is not rare to find, especially at a rather late period for the development of the asci, twigs slightly enlarged for a considerable distance, but bearing no asci. The fungus in structure is rather closely related to *Exoascus pruni*, and at one time I considered it identical with that species. Specimens collected by myself in Alabama were distributed by Seymour and Earle* as *Taphrina deformans* (Berk.) Tul.

The asci are slightly clavate, rounded or truncate at the free ends, and measure 25–45 long by 8–10 in diameter. The stalk cells are 10–18 high by 5–8 in diameter, and are usually rounded or truncate at the base. They do not intrude between the cells of the epidermis. The spores are quite regularly elliptical, or rarely oval, agreeing in this respect somewhat with the spores of *Exoascus rostrupianus** Sadeb. but not so large as in that species.

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* Economic Fungi, No. 129.

The mycelium is very abundant in the tissues of the affected buds, forming a very complex network of threads between the cells of the hypertrophied tissue. The details of structure are shown in figures 61 and 62.

The same fungus also occurs in Iowa, specimens collected on *Prunus angustifolia* (P. chicasa) in Chickasaw Co., by Prof. L. H. Budd, were communicated to me by Prof. L. H. Pammel.

The mycelium is perennial in the branches, and in the following spring the young buds from such branches are more likely to suffer from attack.

Exoascus mirabilis var. *tortilis* n. var.

This form occurs on the fruit of *Prunus angustifolia*, very rarely producing the plum "bladders," and then the fruit is only affected on one side and is strongly curved. Usually the attack is confined to a rather small area or so small that a considerable portion of the fruit retains its normal form and color, and it is not hollow within. The structure of the fungus is but little different from that on the buds, the chief differences being in somewhat larger development, so that the asci are somewhat longer and the stalk cells higher. The other characters, including those of the mycelium are the same as in the form on the buds. The propriety of separating the form on the fruit as a variety may be questioned, but it seems well to do so in order to avoid possible confusion, since the form on the buds is the more common one in localities where I have observed it, and quite frequently trees may present many buds which are affected when all the fruits are free from attack.

Erwin Smith† notes the occurrence of both these forms on *P. angustifolia* and its cultivated varieties in Maryland and Georgia. He suggests that it may be distinct from the *E. pruni*.

Many of the native trees are very seriously affected, and it seems in some cases to be spreading and becoming serious in the plum orchards in the southern states.

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*Die parasitischen Exoasceen. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. X, 1, p. 46, 1893.

†Jour. Mycology, p. 108, vol. VI.

PRUNUS HORTULANA L. H. Bailey.

Exoascus mirabilis. Atkinson.

The buds and ends of the branches of *P. hortulana* are affected exactly like those of *P. angustifolia*, and the fungus seems to be identical with the species on that plant. All of the specimens were communicated to me by Prof. Pammel. Some of the details of the asci, etc., are illustrated as follows. Fig. 70 from specimens collected at Ames, Iowa, in May, 1894; fig. 72 from specimens collected by Dr. A. B. Dennis at Cedar Rapids, Ia., May, 1894. These specimens which I examined were rather young and comparatively few of the asci were fully developed. Fig. 68 is from specimens collected by Mrs. R. M. Kellum, at Salem, Ia., June 8, 1894. In this specimen the asci and stalk cells were much longer than in any of the other specimens, though the relative proportions between the asci and stalk cells remain about the same. This specimen was marked "*Prunus chicasa*, 'Wild Goose Plum.'" Prof. Bailey has determined it as *P. hortulana*.

Figs 70 and 72 agree in all respects with the type.

Fig. 71 represents the asci and the relation of the fruit structures to the epidermal cells in specimens from the buds of *Prunus hortulana* var. *mineri*, also from Iowa, collected by A. Noe, in May, 1894. These also agree with the type on *P. angustifolia*.

PRUNUS AMERICANA Marshall. Wild Red Plum.

Exoascus longipes n. sp.

The specimens which constitute the type of this new species were collected at Danby, N. Y., by T. A. Mandeville. A photograph of the twig bearing numerous "bladders" and a normal fruit is reproduced in fig. 3, Plate II. The hypertrophied fruits are irregularly long ovate and sometimes slightly curved. The fungus is quite different from any of this class described hitherto on the fruits of *Pruni*. It is characterized chiefly by the very long stalk cells and from the circumstance that they intrude themselves prominently between the cells of the epidermis. The asci are slightly clavate and rounded or somewhat truncate at the free end. They are 30–40 long by 7–10 in diameter. The stalk cells are 25–35 high by 3–5 in diameter, being usually much narrower below. The lower ends of the cells of the hymenium begin usually to intrude themselves between the cells of the epidermis at quite an early stage of development. Fig. 47 shows this relation of the cells of the hymenium to the epidermal cells. This results from a peculiarity of the development of the ascogenous cells from the first mycelium which spreads beneath the cuticle. The growth from these cells proceeds inward, that is, toward the epidermis, as well as outward in the direction of the formation of the ascus. This is quite markedly the case in all the long stalked species of *Exoascus* which I have examined, even of *E. pruni*, *E. communis*, *E. mirabilis*, and others. It is however much more marked in this species than in those just quoted, especially the long inward growth of the stalk cells. After many of the asci are quite well developed and are somewhat crowded, the hymenium continues to increase in a peculiar manner in all of these species but more so in some than in others. An ascogenous cell develops somewhat below the middle a slender branch which grows inward toward the epidermis. After having grown downward for some distance, sometimes having reached a length of 15–20, the outer end begins to grow outward to form the ascus. A series of these with a young ascus is shown in fig. 49. In this way the lower ends of the stalk cells will frequently be at a very irregular line, some of them not intruding between the cells of the epidermis while others are crowded far down between them. *Exoascus rostrupianus* probably develops the later hymenium in this way to judge from Sadebeck's description, and also from the fact that it is a long stalked species. But according to Sadebeck* the stalks do not intrude themselves in the least between the epidermal cells. The spores are also quite different, being quite constantly elliptical, and the conidial formation from budding of the spores in the ascus being very rare. The spores in *E. longipes* are round or oval, measuring 3–4 in diameter.

When the asci are developing from these later hymenial cells it frequently happens that the septum separating the stalk cell from the ascus is formed below the connection of the fruit body with its neighbor from which it had its origin.

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* Die parasitischen Exoasceen. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. X, 2 p., 29, 1893.

The mycelium is very abundant in the tissues of the hypertrophied fruits, forming a well developed network of threads between the cells as in other species of this type.

These are the only specimens on *P. americana* Marshall of this species which I had the opportunity to examine. Other specimens of hypertrophied fruits of *P. americana* were collected near Ithaca, N. Y., during June, 1894, and judging from a photograph which I have seen of them the form of the hypertrophied fruit is quite different. The specimens have either been mislaid or lost so that at this time there is no means of examining them to see whether they belong to this species or to *E. communis* Sadebeck.

Exoascus communis Sadebeck.

Sadebeck* reports this species on *Prunus americana* Marshall from the United States, collected by Bartholomew. To it I have also referred specimens collected by Seymour at Madison, Wis., June 3, 1886, and distributed as *Taphrina pruni*† (Berk.) Tul.

Specimens on the fruits of cultivated varieties of *P. americana* communicated by Prof. Pammel, and collected in Iowa, show a much distorted fruit in many specimens, especially of the "Cheny" variety. In some of these fruits only one side appears to be affected, resembling in this respect very much, the fruits of *P. angustifolia* deformed by *E. mirabilis* var. tortilis Atkinson. The form of the stalk cells also seems to be nearer those of that species than of *E. communis*, and I do not feel like definitely locating the form until we know more about the relation of these hypertrophied fruits of the cultivated varieties of *P. americana* to the deformed buds which also occur on *P. americana*, and which appear to be identical with those on *P. angustifolia* and *P. hortulana*.

The asci of the "Cheny" and "Baldwin" varieties of the form on the fruit of *P. americana* are shown in detail in figures 40–43, 42 representing the asci of the Baldwin variety.

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* Die parasitischen Exoasceen. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. X. 2, p. 47, 1893.

† Seymour and Earle, Economic Fungi, No. 13.

Exoascus mirabilis Atkinson.

To this species I refer the form on the buds of *P. americana* Marshall, from Iowa, specimens communicated by Prof. Pammel, and by Prof. Seymour. The asci, stalk cells and spores are shown in figs. 68 and 69.

Specimens of probably this same species on the buds of the Maquoketa* plum were reported from Iowa in 1888, the Maquoketa being here inadvertently referred to the Chickasaw plum.

Exoascus decipiens n. sp.

This species distorts the leaves and young shoots of *Prunus americana* Marshall. Specimens have been collected at Danby, N. Y., by T. A. Mandeville, and at Aetna, N. Y., by the writer. A photograph of two of the specimens from Danby are reproduced in figs. 5 and 6, Plate III. The young shoot is somewhat enlarged, though there are developed no asci on any of the shoots which I have seen. In fig. 5 some of the leaves can be seen to be finely wrinkled near the base. The affected part of the leaf is usually thrown into a series of very fine folds or wrinkles, and the under surface, which at the time of the maturity of the asci is frequently farther injured, presenting a scurvy appearance, is covered by scattered groups of rather loosely associated asci. No asci have as yet been found upon the upper surface, and from careful examination I have not been able to detect any development corresponding to the "witches brooms," so that the species seems to be well differentiated from *E. insititiae* Sadeb. The asci are also much larger and different in other respects than those of that species. They are nearly cylindrical and rounded or rarely truncate at the free ends, and measure 20–40 long by 7–10 in diameter. The stalk cells are quite broad, frequently broader than the asci, and measure 6–13 high by 7–12 in diameter. They are usually rounded below, but sometimes are pointed much as in *E. deformans* on the peach. The spores are oval or broadly elliptical, measuring 3–4 in diameter. Quite frequently conidia are developed by budding while still within the ascus.

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* Report Dept. Agr. p. 368, 1888.

Where the leaves are fully expanded or nearly so before they are seriously attacked the injury is confined chiefly to the base of the leaf and the petiole. Sometimes isolated spots nearer the tip of the leaf are also affected. If the leaves are seriously attacked when quite young they become killed, still clinging to the branch and with no development of asci dry, become crisp, and black. The blades of leaves only partially affected also become black, the lamina first and the petiole later, especially when the serious attack is chiefly confined to the base of the leaf. This dying of the affected parts often continues into the shoot, which presents also a blackened appearance. One of these shoots with blackened leaves in different stages of development is reproduced from a photograph in fig. 17, Plate VIII.

The mycelium is perennial in the young branches, and occurs in the intercellular spaces of the affected parts.

See figurus 74–77, Plate XIX, for details.

Fig. 5, Plate III, shows also the fruits of *P. americana* deformed by *Exoascus longipes* Atkinson, growing from the same shoot as *Exoascus decipiens* and very near it. In the shoot the mycelium of the two species is probably somewhat intermingled, but there can be no doubt about the two being different species, for they represent very remote types of *Exoascus*.

Exoascus decipiens var. *superficialis* n. var.

On half formed fruits of *Prunus americana* Marshall, at Aetna, N. Y., I have found an *Exoascus* which may prove to be a distinct species. I have not had as yet sufficient material to give it the careful study to determine this point. I therefore prefer at the present to place it as a variety of *E. decipiens* Atkinson, especially as it occurs in the cases thus far observed on the same tree on which I collected *E. decipiens* at Aetna, N. Y. The first specimens were collected July 6, 1894. At this time the *E. decipiens* on the leaves had nearly disappeared, at least the fruiting condition of it. The fungus on the fruit at this time was not mature, but was collected in a mature condition on July 28. The fruits as stated above are half formed and the stone is normal, or at least not wanting. For this reason I have proposed the name *superfi-*

cialis. On the affected parts the mycelium penetrates to some depth, however, in the tissue and warty swellings appear, or a large part of the surface is laid under contribution to the fungus. Two of these hypertrophied fruits showing the extremes of this condition are reproduced in fig. 7, Plate III.

On the specimens which were collected July 28, the surface of these warty projections was roughened and finely cracked, and beside the mature asci which were present there were other fungi of a saprophytic nature, especially a specimen of Cladosporium, though not in profusion. The hymenium was upon the surface of this tissue. The asci are about 25–30 long by 8–11 in diameter, and some of them presented a constriction near the base. The stalk cell in the specimens seen were very short, but farther study is necessary to determine these characters. The asci, however, are near the type of those on the leaves. Whether the mycelium is perennial in the branches and grows out into the fruits, or whether infection takes place by spores from the species on the leaves cannot at this time be stated. If the former were the case there would seem good ground for considering it as a distinct species.

PRUNUS TRIFLORA Roxburgh. Japan Plum.

Exoascus rhizipes n. sp.

This very interesting species was collected by the writer on Japan plums of the variety sometimes called Botan, or Botankio. It was collected at Auburn, Ala., May 1, 1892. Superficially the hypertrophied fruit and buds resemble those on the Chickasaw plum (*P. angustifolia*). One specimen, in which an affected fruit and bud were growing very close together on the same branch, was photographed and is reproduced in fig. 4, Plate II.

While the superficial resemblance is close to the hypertrophies caused by *E. mirabilis* Atkinson, the structure of the fungus is very different, and also differs markedly from any described species. It is more closely related to *E. longipes* Atkinson, but differs from that in the stalk cells which intrude much farther between the cells of the epidermis and by the frequent development of numerous rhizoids which are intermingled with the stalk cells and also penetrate between the epidermal cells. The lower part of the slender stalk cell is frequently septate as are also the rhizoids. The stalk cells of *E. longipes* occasionally possess a few rhizoids, and this is the case in many of the long stalked species, but the occurrence on those species is rare. These rhizoids are developed both from the stalk cells and from the lower part of the ascus. Their origin is related, or similar in kind, to that of the development of the later portions of the hymenium in this and other species noted under the discussion of *E. longipes*.

A very thin section presents the appearance as if there were no stalk cells whatever, but that the asci arose from a very complex cellular hymenium of several layers in thickness, the inner layers of which are between the epidermal cells of the host.

The typical form is on the fruit and the structure of the asci and the relation of the stalk cells is shown in Plate XV, figs. 53–57. Some young developing asci.from the fruit are shown in fig. 57, with a few rhizoids and young hymenial cells. The older asci are difficult to tease out well from their attachment in the epidermal cells so as to preserve all the rhizoids in situ. The asci are slightly clavate, are 30–40 long by 8–10 in diameter. The stalk cells reach a length of 25–35 or 40, and are 3–5 in diameter. The rhizoids and stalk cells as well are frequently septate. This occurs sometimes also in *E. longipes* but rarely compared with the occurrence in this species.

The young cells of the hymenium also more early intrude themselves between the cells of the epidermis. The intercellular mycelium is abundant as in the other related species. The spores are elliptical.

The form on the buds is similar, but the development of the rhizoids is not so profuse, nor are they so long. This may be accounted for I think from the fact that the fruit forms a more suitable nourishment and all the structures are forced to a greater development. The same relation exists between the form on the fruit in *E. mirabilis* and that on the buds, but in each case it is quite easy to properly correlate the two forms. On the bud the stalk cells intrude themselves far between the cells of the epidermis, as shown in fig. 53. In fig. 55 are shown three asci with their stalk cells and the connection near the septum dividing the stalk from the ascus.

PRUNUS VIRGINIANA L. Choke Cherry.

Exoascus confusus n. sp.

The fungus causing the hypertrophied fruits of *Prunus virginiana* have been referred, it seems to me improperly, to *Exoascus pruni*. Sadebeck* considers it identical with the *Exoascus* causing the hypertrophied fruits of *P. domestica* and places it in *E. pruni*. The asci are quite different and especially the stalk cells and their proportion to the asci. Figures 37–39, Plate XII, represent the details of these structures. Fig. 37 is from a rather young specimen from Forest Home, N. Y., and figs. 38, 39, from specimens collected by Underwood at Taburg, N. Y., communicated by Seymour. Comparing these figures with those of *E. pruni* from *P. domestica*, shown in figs. 44, 45, a great difference is seen. All of these illustrations of the structure of the asci, etc., are carefully drawn with the aid of the camera lucida to the same scale, so the comparison can well be made from the illustrations. The asci of this species on the fruit of *P. virginiana* are, according to these specimens, 30–45 long by 8–12 in diameter. The stalk cells are 15–30 high by 6–10 in diameter. The stalk cells are nearly or quite the same diameter as the asci and are proportionally longer than those of *E. pruni* on *P. domestica*, and Sadebeck† says upon examination that the fungus upon the fruit of *P. domestica* in the United States is the same as that in Europe upon the same host. The stalk cells also on the fruit of *P. domestica* are also more slender in proportion to the diameter of the ascus than in those on the fruit of *P. virginiana*.

The physiological effect upon the host is also quite different. Not only is the hypertrophied fruit much longer in proportion to the diameter than is the case with the fruit of *P. domestica*, but the floral envelopes are also constantly hypertrophied and become persistent, which is not the case with the same organs of the flower of *P. domestica*. The asci are also developed on the floral organs.

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* Kritische Unters, etc. Ab. a. d. Jahrb. d. Hamb. Wiss. Anst. VIII, 29, 1891.

† Die parasitischen Exoasceen. Ibid. X, 2, p. 44, 1893.

Robinson* calls attention to the fact that the asci on the fruit of *P. domestica* are much more slender than the measurements given by Sadebeck would indicate. In a later contribution Sadebeck† himself indirectly gives some ground for considering this a distinct species from the *E. pruni* on *P. domestica*. In this communication he thinks it possible that a careful examination of the fungus on the fruit of *Prunus padus*, which he previously studied and placed in *E. pruni*,‡ may prove to be a distinct species. The hypertrophied fruits of *P. padus* agree in external appearance more nearly with those of *P. virginiana* than with those of *P. domestica*, and the floral organs of *P. padus* are also hypertrophied. *Prunus padus* and *P. virginiana* both belong to the same type of the genus *Prunus* and to a different type from that to which *P. domestica* belongs.

I should consider the fungus on *P. virginiana* much more nearly related to the *E. farlowii* on *P. serotina* than to *E. pruni*. The relative size of the asci and stalk cells as well as the proportionate length of the same, suggest this, as can be seen by comparing the illustrations of the two. Figs. 34–36 being those of *E. farlowii* and 37–39 being those of the species on the fruit of *P. virginiana*. There are, it seems to me, however, good specific differences between these two, the base of the stalk cells in *E. farlowii* being frequently narrower and running to a point which intrudes somewhat between the cells of the epidermis. The asci of *E. farlowii* are also much shorter, and the stalk cells are proportionately a little broader. I therefore propose for the fungus on the fruit of *P. virginiana*, the name, *Exoascus confusus*.

Exoascus cecidomophilus n. sp.

This is a very interesting species which I have found upon the fruits of *Prunus virginiana* which were deformed by a species of *Cecidomyia*. The species was discovered too late in the season to say whether the larvæ attacked the fruit before or after the attack by the fungus. I believe at this time, however, that the cecidomid larvæ attack and deform fruits which are not affected by the fungus. Certainly the larvæ control to the greater extent the form of the gall, which is very different from that produced by any hitherto known species of the *Exoasceae*. Neither the floral envelopes nor the stamens suffer hypertrophy, the carpel alone being concerned. This is transformed into a peculiar hollow and open gall, the opening being at the base of the ovary and appearing as if it were formed by the cracking away of a portion of the base from the receptacle, as the base of the fruit by hypertrophy increases in size. The peculiar shape of the gall is shown in figs. 15 and 16, Plate VII, reproduced from a photograph. They are from 1.5–2.5 cm. long and somewhat less than 1 cm. in diameter, being two to three times longer than broad. They are somewhat broader than the normal fruit and two to four times longer, as can be seen in the illustration in which are shown a few normal fruits attached to the same cluster. Sometimes only one or two of the fruits in a raceme are affected. This trouble seems to be a very common one in the vicinity of Ithaca, N. Y. It is especially abundant along the Dryden road between Aetna and Varna, where it was first noted by Prof. J. H. Comstock. The gall is nearly oblong in outline, with rounded ends, a slight inflation at the middle and a constriction near the base, so that the very base seems to flame outward as if inverting. It is also more or less curved.

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* Notes on the genus Paphrina. Ann. Bot. I, p. 168, 1887–8.

† Die parasitischen Exoasceen. Ab. a. d. Jahrb. etc. X, 2, p. 45, 1893.

‡ Kritische Unters. etc. Ibid. VIII, p. 29, 1891.

The fungus does not occupy the entire gall and does not penetrate to a very great depth in the tissues, while the mycelium is rather scanty. Sections, however, do show that the mycelium penetrates in the subepidermal tissue to some extent between the cells over a portion of the gall. The side of the gall which is affected by the fungus is more strongly arched than the unaffected side. Whether the slight curve which has thus far been observed to be present to some extent in all the galls examined, is caused by the presence of the mycelium, has not yet been determined. Several have been examined and the mycelium not found, but farther study is necessary to determine this point, and also to determine the exact relation of the cecedomid to it.

Before the galls die if they are cut open, several of the reddish larvæ of the cecidomid will be found inside clustered at the apex of the hollow interior. The cavity is quite large and smooth, and of a dark color.

The tissue of the gall is quite hard, especially so as compared with that of the ordinary "bladders" formed by species of *Exoascus*, and this taken with the scanty mycelium of the fungus and the peculiar shape of the gall is pretty strong evidence that the form of the gall is more strongly influenced by the cecidomid than by the fungus.

The fungus is very different from those which are known to produce the "bladders" or "'pockets" of the fruits of *Prunus*. The asci are cylindrical or slightly clavate and rounded at the free ends. They are 30–40 long by 6–10 in diameter. The stalk cells are very broad, being 6–10 high by 10–15 in diameter. They are usually rounded and blunt below and do not at all intrude between the cells of the epidermis. The asci are scattered or rather loosely aggregated. Figs. 73, 78, 79, illustrate the asci, etc., of this species. The spores are rounded or elliptical, and very frequently the formation of conidia by budding in the ascus takes place. In a few cases I have observed the spores in process of formation before the wall separating the ascus from the stalk cell was formed. Two such cases are represented in fig. 73. One case was observed where no wall was formed even when the ascus was mature and the spores occupied the entire fruit body. A few variations of this kind have been observed in some of the other species. Sadebeck records a case of the beginning of spore formation before the separating wall was developed.

Occasionally on the same trees which bear the cecidomid galls with the *Exoascus cecidomophilus* Atkinson, are the old mummified hypertrophied fruits caused by *Exoascus confusus* Atkinson (*E. pruni* of Authors). Fig. 16, Plate VII, shows a very interesting condition of the fruit which is sometimes seen. A single raceme bears several normal fruits, one mummified fruit the result of the attack of *E. confusus* in May or early June, and several fruits attacked both by a cecidomid and by *E. cecidomophilus* in July.

Exoascus sp

A species of *Exoascus* has been found deforming the leaves and twigs of *Prunus virginiana*, but thus far I have not seen the mature condition though several diligent searches have been made for it. To what species it belongs or whether the one in the shoots is the same as the one in the leaves is not known. A few shoots on one tree by the roadside near Crowbar Point on the west shore of Cayuga Lake were found by me on June 28, 1894. They were enlarged for some distance from the ends and the greater diameter of the hypertrophied shoot was some distance from the end. They were also curved to one side by torsion, usually nearly at a right angle, but in one case the torsion had continued until the shoot made an entire revolution and the end then pointed in nearly the same direction as the main part of the shoot. This one is reproduced in fig. 18, Plate VIII. Some of the leaves of these same shoots were deformed by a species of *Exoascus*. Somewhat similar distortions of the leaves were found along the Dryden road between Aetna and Varna, July 6 and 28. A few only were found on a very few of the shrubs which also possessed the cecidomid galls. None of the shoots here were deformed. An examination of the tissues of the shoots and and leaves thus deformed showed the presence of the mycelium of an *Exoascus*.

Fig. 84 represents the intercellular mycelium in a twig, and fig. 80 the mycelium and very early stage of the formation of the hymenium in a petiole of a very young leaf in a bud of the same.

PRUNUS DEMISSA Walp.

Exoascus varius? Atkinson.

Among other specimens communicated to me by Prof. Pammel was one from the Herb. of Prof. Wm. Trelease, collected in Ute Pass, Colorado, on the leaves of *Prunus demissa* Walp. The affected spots appear to have been arched and slightly folded, forming rather shallow open pockets, much like those which I have here observed on the leaves of *Prunus virginiana*, to which *P. demissa* is closely related. In the specimens observed the asci were developed on the upper surface of the leaves forming a whitish coating to the spots. Some of the asci are illustrated in fig. 33. Without more material and fuller observations I do not care to definitely locate the species. It is marked *Taphrina deformans*. It seems to me that the proportion existing between the length of the stalk cells and the asci is different from that in the specimens on the peach, and agrees more closely in that respect with the fungus on the leaves of *P. serotina* L. which I have referred to *E. varius* n. sp. I would therefore provisionally refer it to that species.

CONCLUSIONS.

It is to be regretted that definite and conclusive experiments have not yet been made concerning the treatment and control of the diseases caused by the various species of the *Exoasceæ*, so that this information, which is most desired by fruit growers could be here confidently placed before them. It is hoped, however, that this contribution will give those interested a greater familiarity with the characteristics of the deformed leaves, fruits, and branches caused by this group of parasitic fungi and that this will lead to a more intelligent line of experimentation.

It should be remembered that the species possess a perennial mycelium which lives in the buds or branches of the trees, during the winter months, of plants which once have become infected. That a tree once affected is likely to show the disease more or less every year. Climatic conditions probably influence a greater or less injury from year to year, so that in some years little of the trouble may be observed when in other years it is more common. This has led some to suppose that the fungi are not perennial, but that a fresh infection each year is caused by the spores only. This is a mistake. There is abundant evidence from the results of several investigators to show that the mycelium is perennial, for it has been found during the winter months, and in the spring has been traced as it grows from the buds or branches into the young leaves or fruits. It is quite possible that one source of the original infection of trees is from the attacks of spores. I have several times attempted to inoculate healthy peach trees, or unaffected ones, from the spores taken from freshly mature specimens on affected trees. This I attempted at Auburn, Ala. Not only were spores sown on the young leaves and buds, but pieces of the leaves containing mature spores, and others containing the mycelium only were inserted into a slit in young buds and in the young branches near buds. In no case did any sign of the disease appear even after three years. Several of these incisions were wrapped with moist cloth and kept moist for several days, while in other cases a moist chamber was made around the twig by covering it with quite a large test tube. Had young buds been inserted in the manner of budding during the month of August in all likelihood the disease would have appeared in a year or two. I know of no successful experiments made in inoculating peach or plum trees from the spores, although such results may have been attained. It is usually considered by most students of this group that it is rather difficult to secure results from the inoculation by spores in many of the species of *Exoascus* while in others it is comparatively easy. Sadebeck* succeeded in inoculating *Alnus incana* with the spores of *Exoascus epiphyllus*, and producing the characteristic disease. He says it is easier to produce an infection with this species than with any other of the species of *Exoascus* known to him.

Since the mycelium is perennial in the buds or young branches of affected trees no buds should be taken from such trees for budding nursery stock or budding in the orchard. Since nearly all of the affected leaves of the peach trees fall away before the time for the selection of buds, the trees should be carefully selected in the months of May and June in order to avoid those which have the disease.

Where only a few branches of a tree are affected, pruning a considerable distance below the affected portion might be tried, especially in the case of those plum trees affected with *E. mirabilis*, that is those having the bud deformations.

It may be well in concluding to give a list of the species of *Exoascus* described here as occurring on species of Prunus in the United States, with their host.

Exoascus deformans (Berk.) Fuckel, deforming the leaves and rarely the shoots of *Prunus persica* L.

Exoascus pruni Fuckel, deforming the fruit, causing "bladders" or plum "pockets" of *Prunus domestica* L.

Exoascus insititiæ Sadebeck, causing "witches brooms" and deforming the leaves of *Prunus pennsylvanica* L.

Exoascus cerasi (Fuckel) Sadebeck, causing "witches brooms" and deforming the leaves of the same on *Prunus avium*.

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* Kritische Unters, etc., 1891.

Exoascus confusus Atkinson, deforming the fruit and floral envelopes of *Prunus virginiana* L.

Exoascus farlowii Sadebeck, deforming the fruit and floral envelopes of *Prunus serotina* L.

Exoascus communis Sadebeck, deforming the fruits of *Prunus maritima* Wang., *P. pumila* L., *P. americana* Marshall, *P. nigra* Aiton.

Exoascus longipes Atkinson, deforming the fruit of *Prunus americana* Marshall.

Exoascus mirabilis Atkinson, deforming the leaf buds and twigs, forming "pockets," of *Prunus angustifolia* Marshall, *P. hortulana* L. H. Bailey, *P. americana* Marshall.

Exoascus mirabilis Atkinson var. *tortilis* Atkinson, distorting the fruit of *Prunus angustifolia* Marshall.

Exoascus rhizipes Atkinson, deforming the fruit and leaf buds of *Prunus triflora* Roxburgh.

Exoascus decipiens Atkinson, deforming the leaves and shoots of *Prunus americana* Marshall.

Exoascus decipiens Atkinson var. *superficialis* Atkinson deforming the surface of the fruit of *Prunus americana* Marshall.

Exoascus varius deforming the leaves and shoots of *Prunus serotina* L. and ? *P. demissa* Wang.

Exoascus cecidomophilus Atkinson, affecting cecidomid galls on the fruit of *Prunus virginiana* L.

GEO. F. ATKINSON.

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EXPLANATION OF THE PLATES.

All the illustrations in Plates X–XIX inclusive were drawn with the aid of the camera lucida to the same scale. One millimeter of the eye piece micrometer scale of this combination is drawn in each plate. The figures are magnified 30 times more than this scale.

Plate I. Exoascus deformans (Berk.) Fuckel, on leaves of Prunus persica (L.), peach. Fig. 1 from Ithaca, N. Y. The petioles and a portion of the stem are here also affected. Fig. 2 from Auburn, Ala.

Plate II. Fig. 3, Exoascus longipes Atkinson, in fruits of Prunus americana Marshall. One young plum at the right is sound and serves for comparison with the hypertrophied fruits. From N. Y.

Fig. 4, Exoascus rhizipes Atkinson, on fruit and bud of Prunus triflora Roxburgh, Japan plum. From Auburn, Ala.

Plate III. Figs. 5 and 6 Exoascus decipiens Atkinson in the leaves of Prunus americana Marshall. In 6 the shoot is deformed. In 5 the fruits are deformed by E. longipes Atkinson. From N. Y.

Fig. 7, Exoascus decipiens var. cecidomophilus Atkinson in half grown fruits of Prunus americana Marshall. The plum at the left shows but a few warty excrescences, while the one at the right is affected over a large part of the surface. From Aetna, N. Y., on the same tree on which E. decipiens was collected. Fig. 17 in Plate VIII is E. decipiens Atkinson from the same tree, on which the plums in fig. 7 were collected.

Plate IV. Exoascus mirabilis Atkinson var. tortilis Atkinson, in fruits of Prunus angustifolia Marshall (P. chicasa Michz.). Only one side of the fruit is attacked. In each figure one healthy and one affected fruit is shown. From Auburn, Ala.

Plate V. Exoascus mirabilis Atkinson in buds of Prunus angustifolia Marshall. In figure 10 several of the leaves were fully expanded before the bud was severely attacked. Fig. 12 Exoascus mirabilis var. tortilis Atkinson on fruits of P. angustifolia Marshall. All from Auburn, Ala.

Plate VI. Exoascus farlowii Sadebeck, in carpels of Prunus serotina L. Some of the carpels are not attacked and the flowers form a means of comparison with the affected ones. From Auburn, Ala.

Exoascus varius Atkinson, in the leaves and shoots of the same branches. The shoots are deformed and enlarged at the ends but are not developing "witches' brooms."

Plate VII. Exoascus cecidomophilus Atkinson, in fruits of Prunus virginiana L. deformed by cecidomid larvæ. In fig. 16 the strongly arched sides of the galls are the places where the Exoascus is located. Midway of the raceme is a mumified fruit which was deformed by Exoascus confusus Atkinson, earlier in the season. In each raceme are healthy fruits. From near Aetna, N. Y.

Plate VIII. Fig. 17, Exoascus decipiens Atkinson, blackening the leaves and shoot of Prunus americana Marshall. From Aetna, N. Y.

Fig. 18, Exoascus sp. deforming the shoot and leaves of Prunus virginiana L. From near Crowbar Point, west shore Cayuga Lake, N. Y.

Plate IX. Exoascus communis Sadebeck. Deforming the fruits of Prunus pumila L. From Horticultural grounds, Cornell University.

Plate X. Figs. 20–22. Exoascus deformans (Berk.) Fuckel. *a.* ascus, *st.* stalk cell, *hy.* cells of the hymenium, *ep.* epidermis, *m.* mycelium. Fig. 20 from LaFayette, N. Y., fig. 21, from Temple, N. H. Some of these asci have but four spores. Fig. 22 from Ames, Iowa.

Figs. 23, 24, Exoascus insititiæ Sadebeck, on leaves of Prunus pennsylvanica L., from Temple, N. H.

Fig. 25, Exoascus cerasi (Fuckel.) Sadebeck, from leaves of Prunus avium L., Germantown, Penn.

Plate XI. Figs. 26–32, Exoascus varius Atkinson on leaves of Prunus serotina L. Figs. 26–29 from Auburn, Ala., 30–31 from Smyrna, Del., 32 from Temple, N. H. Fig. 33 E. varius? from leaves of Prunus demissa Walp., Ute Pass, Colorado.

Plate XII. Figs. 34–36, Exoascus farlowii Sadebeck, on fruits of Prunus serotina L. Figs. 34–36 from Auburn, Ala., 35 from London, Canada.

Figs. 37–39, Exoascus confusus Atkinson, on fruits of Prunus virginiana L. 37 from Forest Home, N. Y., 38, 39, from Taburg, N. Y.

Plate XIII. Figs. 40–43, Exoascus communis Sadebeck? or E. mirabilis var. tortilis Atkinson? From deformed fruits of Prunus americana, cultivated varieties; 40, 41, 43, Cheny variety, 42, Baldwin variety. From Iowa.

Figs. 44, 45, Exoascus pruni Fuckel on fruit of Prunus domestica L., from Wisconsin.

Plate XIV. Exoascus longipes Atkinson, on fruit of Prunus americana Marshall. Fig. 46, section showing young hymenium etc., *c.*, cuticle, *h.*, hymenium, *ep.*, epidermis, *m.*, mycelium. 47, older hymenium showing the lower ends of the cells making their way in between the cells of the epidermis. 48, 50, 51, mature asci showing the stalk cells penetrating between the cells of the epidermis. 49, showing the successive development of the later hymenium and ascogenous cells. 52, a portion of the fruit where the subcuticular mycelium was not well distributed. From Danby, N. Y.

Plate XV. Exoascus rhizipes Atkinson, on fruit and bud of Prunus triflora Roxburgh. 53 and 55 from bud, 54, 56, 57, from fruit. Fig. 54 shows the young hymenium with the lower ends of the cells growing down between the cells of the epidermis. In the mature asci specimens are seen the rhizoids growing from the stalk cells. 57 represents some of these growing from the lower part of the ascus. Older fruit bodies have a much greater number of rhizoids. From Auburn, Ala.

Plate XVI. Exoascus communis Sadebeck. Figs. 58 and 59 from fruit of Prunus maritima Wang., Dartmouth, Mass. 60, from fruit of Prunus nigra Aiton, Alma, Mich.

Plate XVII. Figs. 61, 62, 63, 66, 67, Exoascus mirabilis Atkinson. 61 and 62 (type) from bud of Prunus angustifolia Marshall, Auburn, Ala., 63 from same in Iowa, 66 and 67 from buds of Prunus americana, Iowa.

Figs. 64 and 65, Exoascus mirabilis var. tortilis Atkinson, on fruit of Prunus angustifolia Marshall, from Auburn, Ala.

Plate XVIII. 70 and 72, Exoascus mirabilis Atkinson on buds of Prunus hortulana, L. H. Bailey, from Iowa, 71 same on P.

hortulana var. mineri., from Iowa. Fig. 68, highly developed specimens on bud of P. hortulana, Iowa. Fig. 69 from bud of Prunus domestica, N. J.

Fig. 73, Exoascus cecidomophilus Atkinson, on fruits of Prunus virginiana L. deformed by cecidomid larvæ. From Aetna, and other places in the vicinity of Ithaca, N. Y.

Plate XIX. Figs. 74–77, Exoascus decipiens Atkinson, on leaves of Prunus americana Marshall, from Danby, N. Y.

Figs. 78 and 79 Exoascus cecidomophilus Atkinson from fruits of Prunus virginiana L. deformed by cecidomid larvæ. In the vicinity of Ithaca, N. Y.

Plate XX. 81, 82 and 83 Exoascus mirabilis Atkinson from Prunus angustifolia Marshall, Auburn, Ala. 81 young hymenium and intercellular mycelium, 82 mature asci showing the connection of a portion of the hymenium with the mycelium, 83 superficial view of a portion of the hymenium. These figures are drawn to a different scale from 84 and 80 and this entire Plate is reduced more than Plates X–XIX.

Fig. 80 is from a petiole of a deformed bud and 84 from a deformed shoot of Prunus virginiana L. on which the fungus was not mature. In 80 is shown the intercellular mycelium and the very beginning of the hymenium underneath the cuticle. In 84 is shown a portion of the intercellular mycelium, after treatment with chloral hydrate.

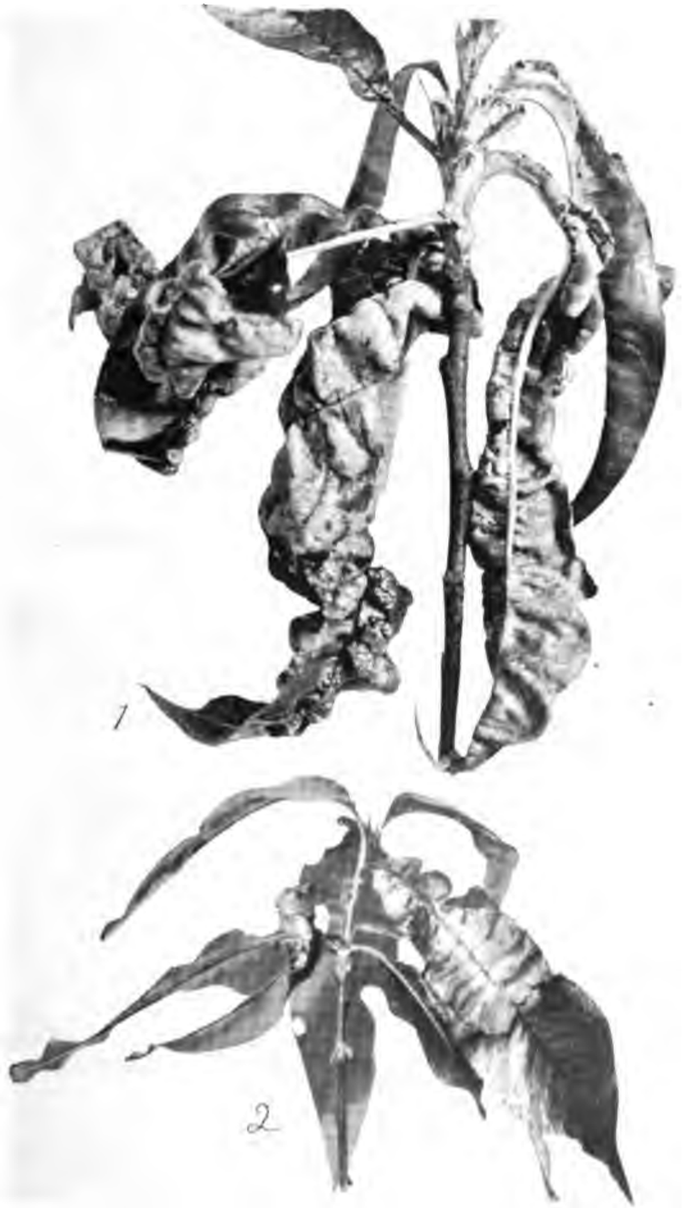


PLATE I.—*Prunus persica* (*L.*), *Peach.* (*Exoascus deformans* (*B.*) *Fuckel.*)

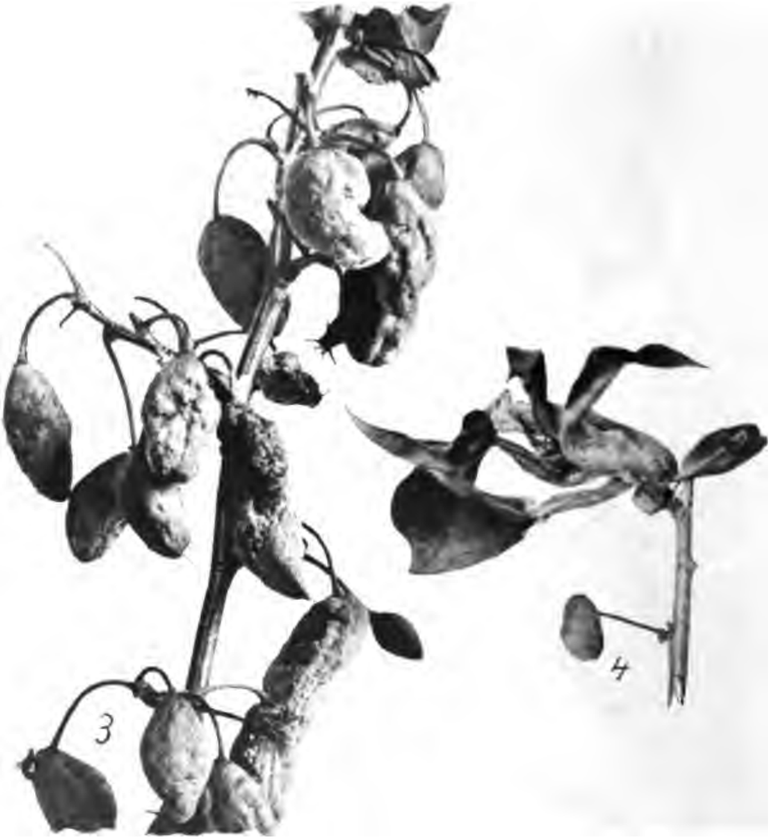


PLATE II.—*Fig. 3.—Prunus americana Marshall, wild red plum (Exoascus longipes Atkinson). Fig. 4, Prunus triflora Roxburgh, Japan plum (Exoascus rhizipes Atkinson).*

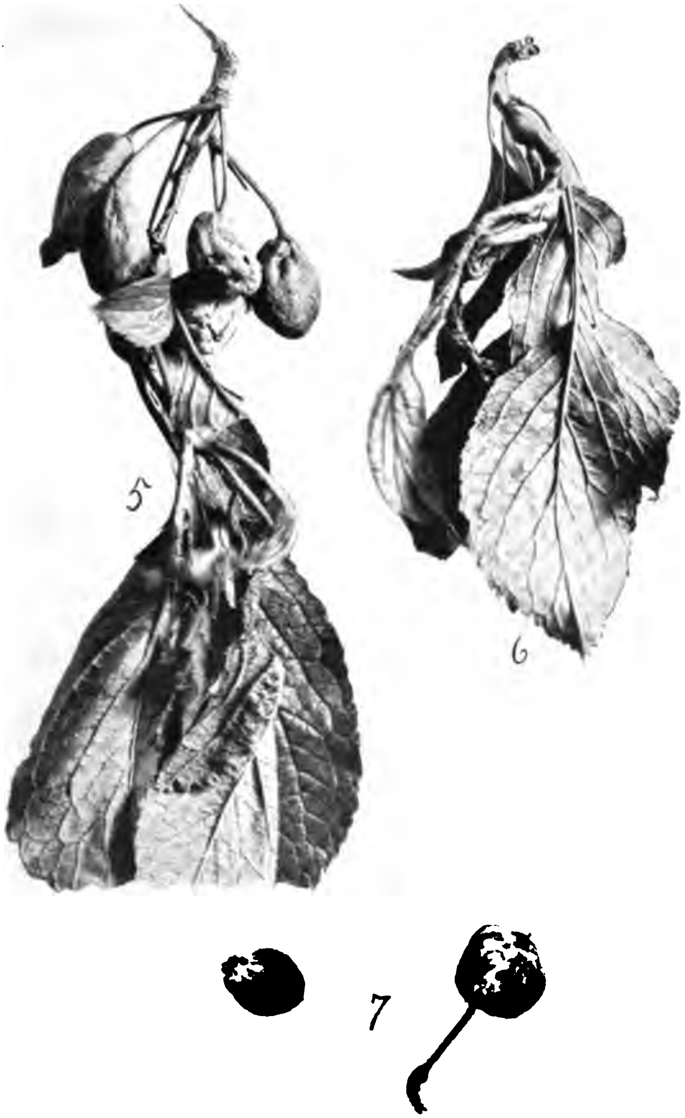
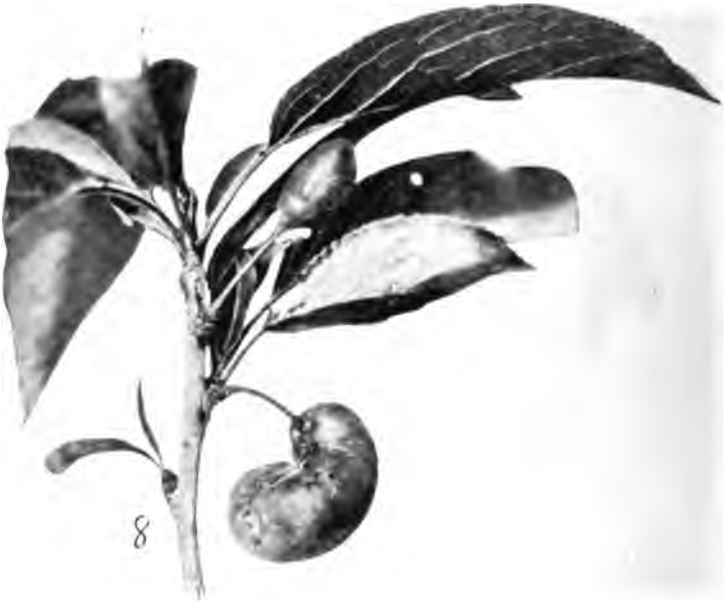


PLATE III.—*Prunus americana Marshall, wild red plum* (*fig. 5 Exoascus longipes Atkinson, in ovaries; E. decipiens Atkinson in leaves, fig. 6, E. decipiens Atkinson in shoot. Fig. 7, E. decipiens Atkinson var. superficialis Atkinson, in surface of half grown plums*).



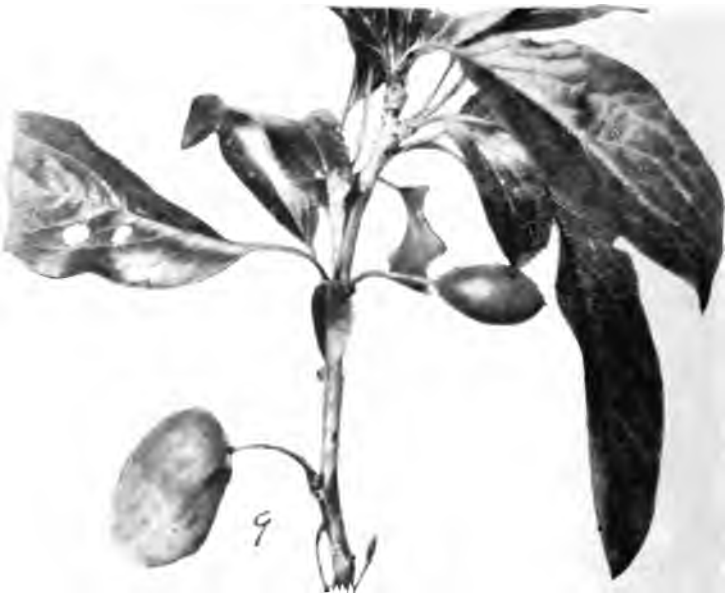


PLATE IV.—*Prunus angustifolia Marshall, Chickasaw plum* (*Exoascus mirabilis Atkinson var. tortilis Atkinson in plums*).

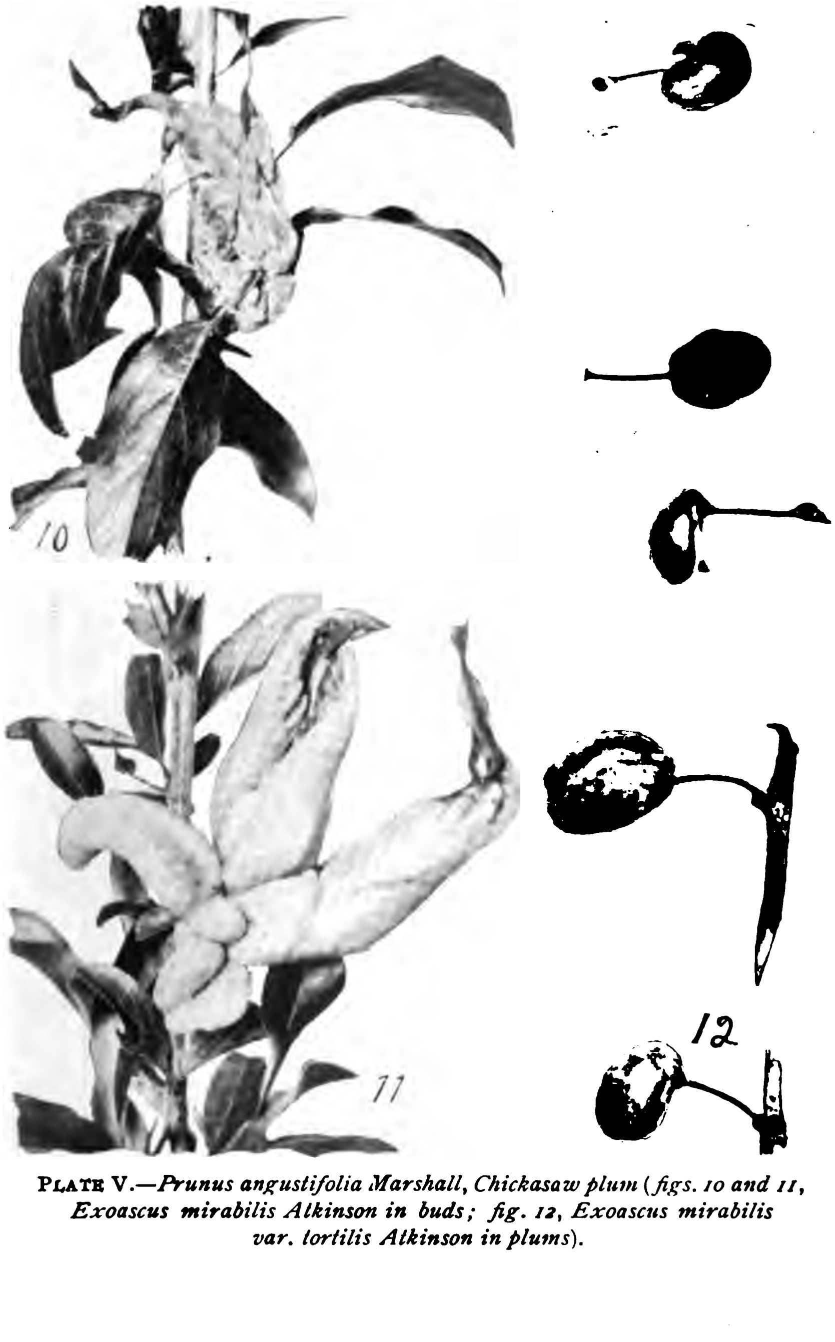


PLATE V.—*Prunus angustifolia Marshall, Chickasaw plum* (*figs. 10 and 11, Exoascus mirabilis Atkinson in buds; fig. 12, Exoascus mirabilis var. tortilis Atkinson in plums*).

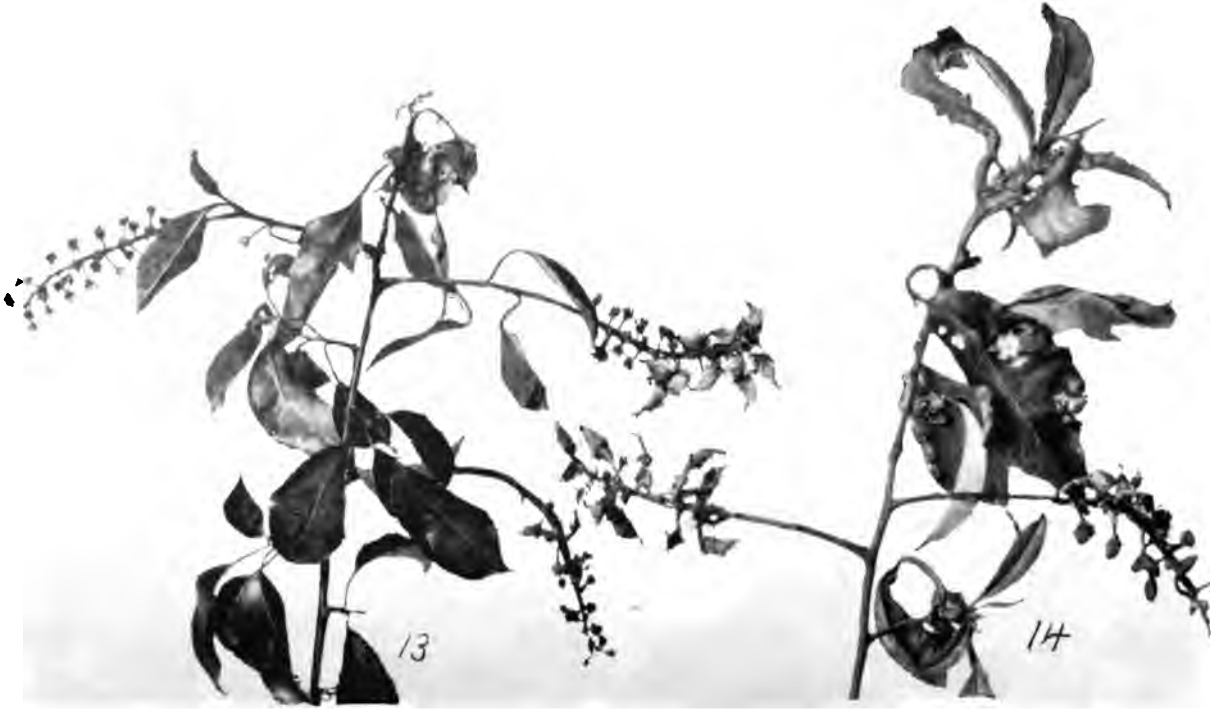


Plate VI.—*Prunus serotina L., wild black cherry (Exoascus farlowii Sadebeck in carpels, Exoascus varius Atkinson in leaves and shoots).*

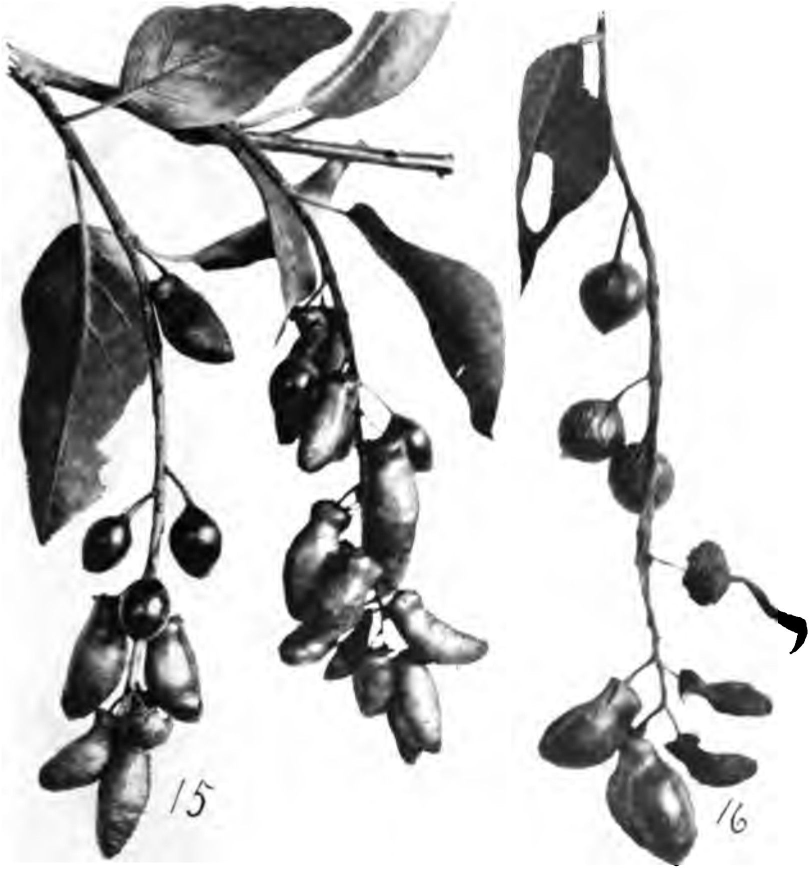


PLATE VII.—*Prunus virginiana L., choke cherry (Exoascus cecidomophilus Atkinson in fruits deformed by cecidomid larvæ.*

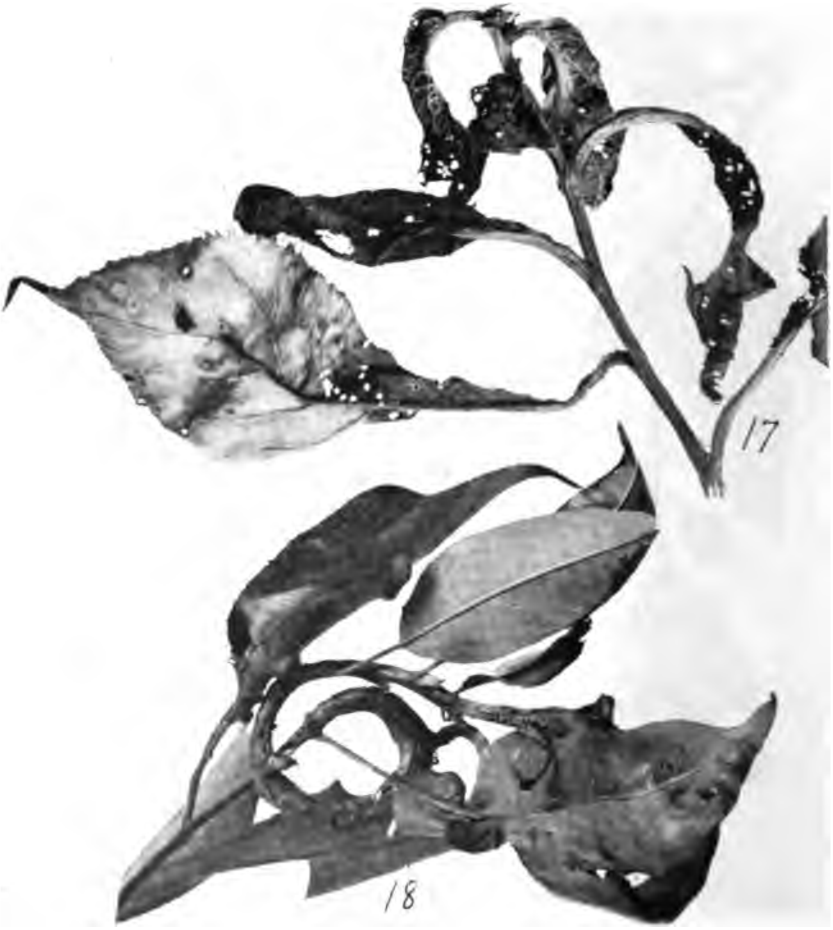


Plate VIII.—*Fig. 17, Prunus americana Marshall, wild red plum* (*Exoascus decipiens Atkinson blackening the leaves and shoot*). *Fig. 18, Prunus virginiana L., choke cherry* (*Exoascus sp. deforming the leaves and shoot.*)

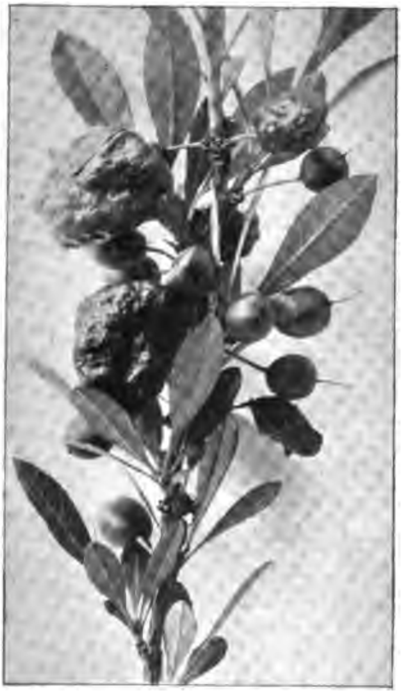


Plate IX.—*Prunus pumila L., dwarf cherry (Exoascus communis Sadebeck).*

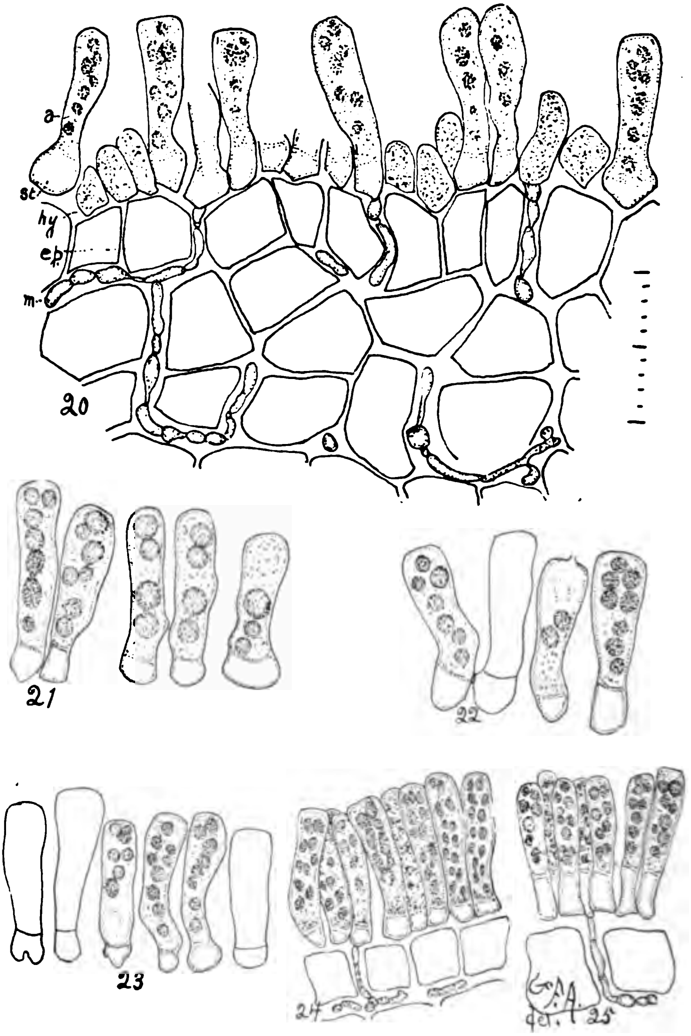
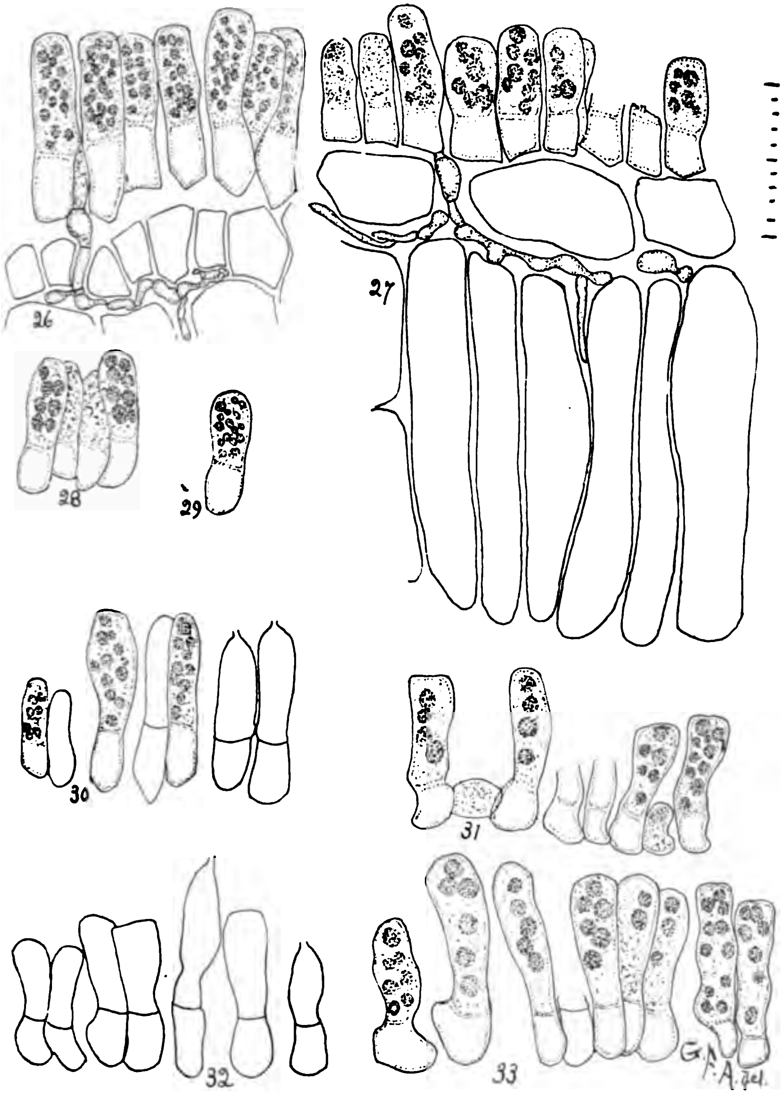


PLATE X.—*Figs.* 20-22, *Exoascus deformans* (*Berk.*) *Fuckel*, (*on P. persica L.*). *Figs.* 23, 24, *Exoascus insititiæ Sadebeck* (*on P. pennsylvanica L.*). *Fig.* 25, *Exoascus cerasi* (*Fuckel*) *Sadebeck*, (*on P. avium L.*).



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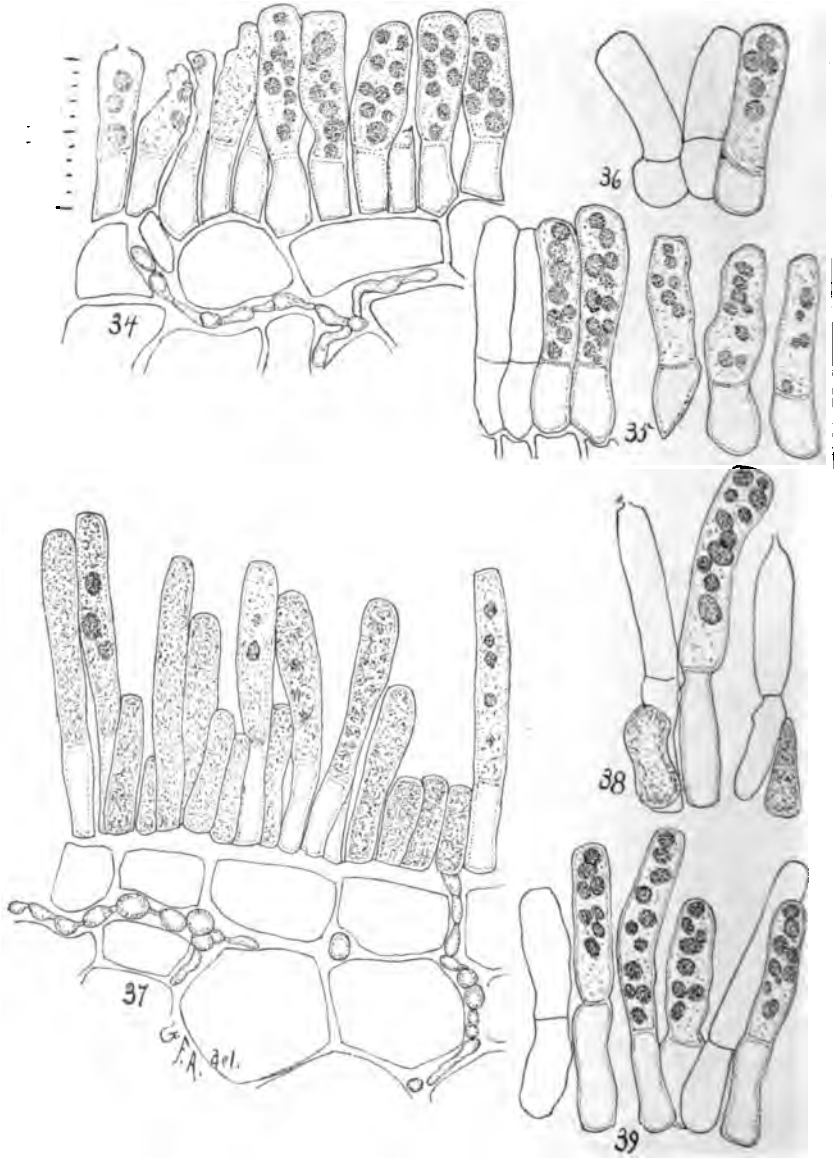

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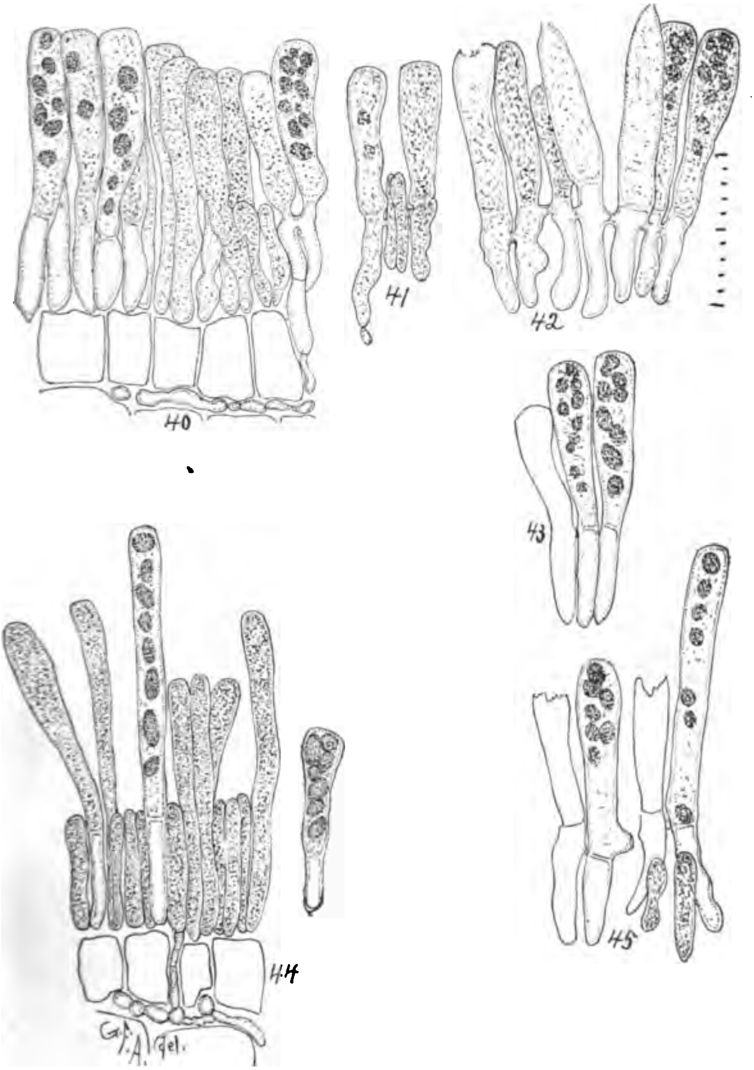

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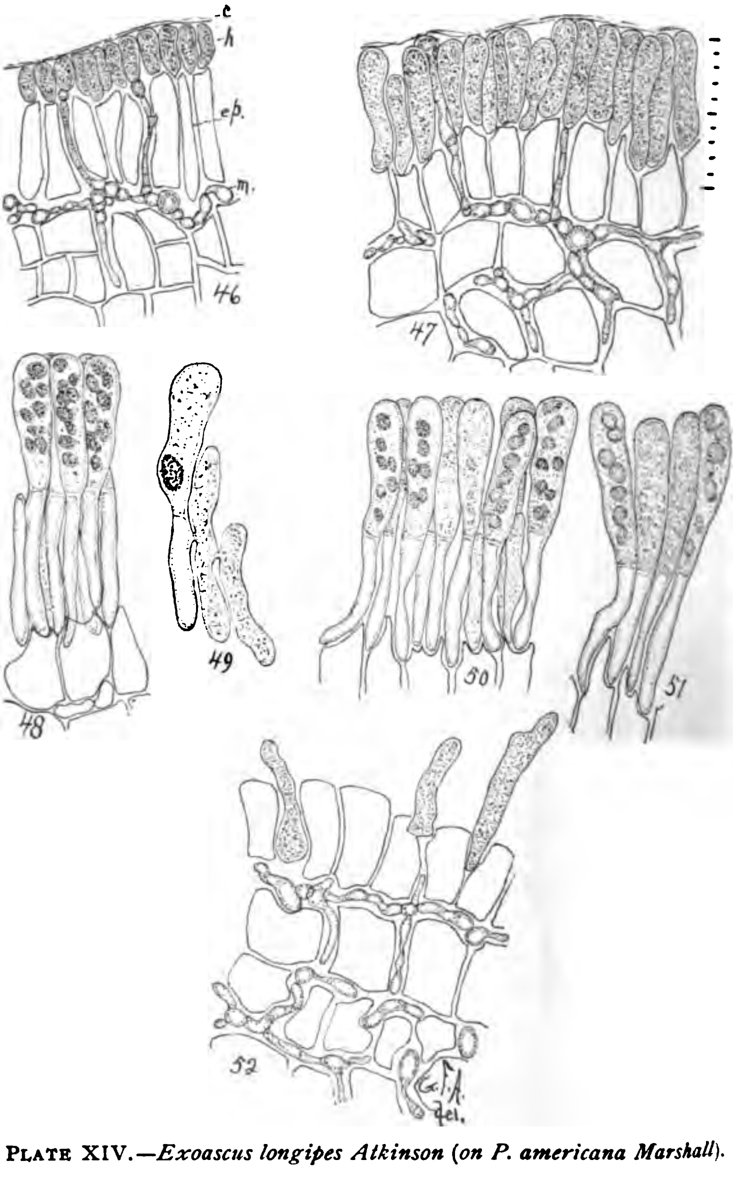

Plate XIV.—*Exoascus longipes Atkinson* (*on P. americana Marshall*).

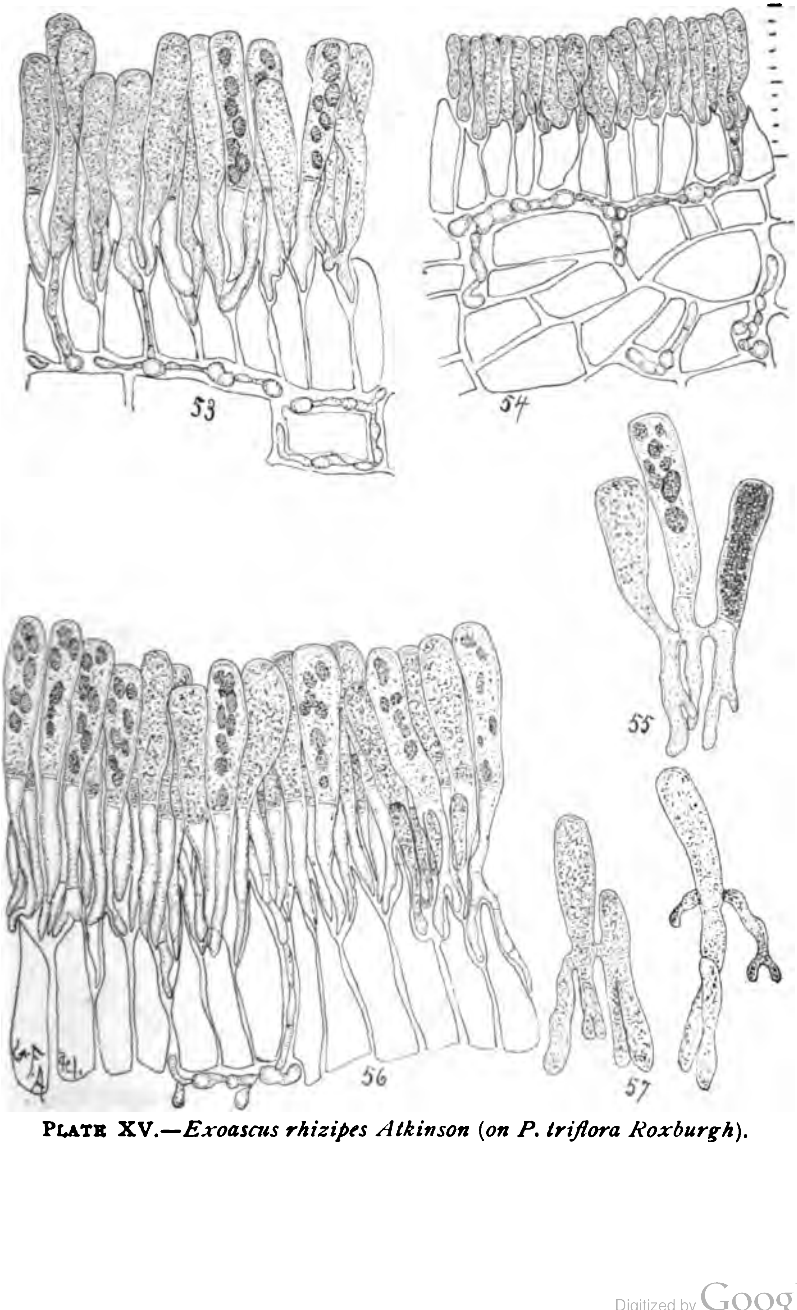

PLATE XV.—*Exoascus rhizipes Atkinson* (*on P. triflora Roxburgh*).

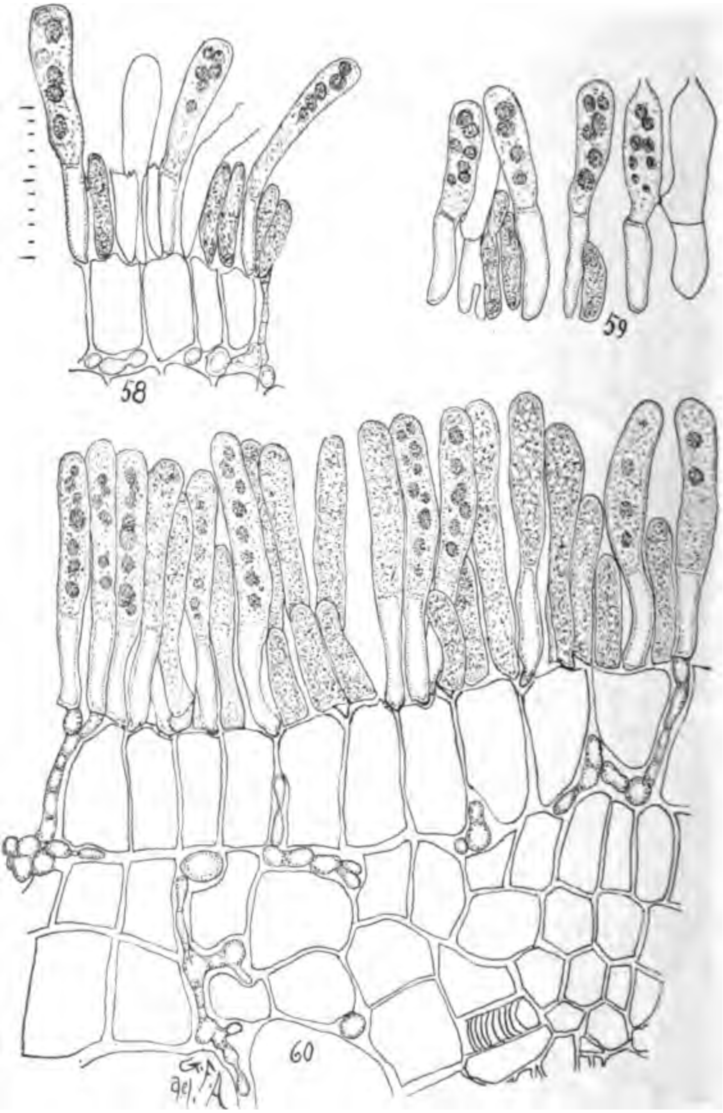

PLATE XVI.—*Exoascus communis Sadebeck* (*58, 59* ***on P. maritima Wang.***, *60* ***on P. nigra Aiton***).

Bulletin 74. October, 1894.

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

IMPRESSIONS OF
THE PEACH INDUSTRY
IN WESTERN NEW YORK.

Page 369.

By L. H. BAILEY.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.

CORNELL UNIVERSITY, ITHACA, N. Y., October 1, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following review of the condition of the peach industry in the Fifth Judicial Department of the state, is submitted for publication under Section 87, Chapter 675, of the laws of 1894. Various experiments in the treatment of peach diseases and in the fertilizing of peach orchard lands are now under way.

L. H. BAILEY.

Timothy Yellows.—"Peaches don't pay." (*Page 374.*)

PEACHES IN WESTERN NEW YORK.

I. GENERAL REMARKS.

ABOUT 9,000 acres are devoted to commercial peach orchards in western New York,—that region from Cayuga and Tompkins counties westward. There are small peach orchards scattered throughout the greater part of this area, except in the southern tier of counties, but the major part of the peach industry is comprised in the Niagara-Ontario district, beginning at Lewiston just north of Niagara Falls, and running eastward along the Ontario slope nearly to Rochester. This district lies in the counties of Niagara and Orleans. There are about 5,000 acres of peach orchard in Niagara county and about 1,000 in Orleans. These orchards, for the most part, lie to the north of the Ridge, which is a natural elevation or embankment lying from five to eight miles back from the lake. The second largest peach district in western New York lies about Seneca Lake. Here there are about 1,000 acres of peach orchards. There are about 400 acres in Livingston county, mostly on the gravelly hills about Mt. Morris; and at this place is the largest peach orchard which I know in the state, that of John F. White, comprising 200 acres. On Keuka Lake there are about 300 acres of peaches, and on Cayuga something less than 200 acres.

After having made a careful study of the horticulture of New York state, I am convinced that the peach industry suffers more from careless and unscientific methods than any other pomological interest. The greatest fault lies in the cultivation, or, I might have said, in the lack of cultivation. The second fault is inattention to borers and yellows; the third is neglect to thin the fruit; and the fourth is carelessness and untidiness in marketing. There are many orchards in western New York which receive every care and attention, but by far the greater number are neglected in one or many respects. I have attempted. during the past summer, to examine carefully every peach district in the Fifth Judicial Department, and I shall here attempt to set down what appear to be the chief defects in our peach industry.

Locations and soils for peaches.—There is much territory in western New York which is admirably adapted to peach growing, but which is now used for other purposes. The slopes adjoining the interior lakes are, no doubt, capable of great development in this direction, for here the severities of winter are tempered and serious late spring frosts are infrequent. The industry could be extended to several times its present dimensions in the Niagara-Ontario district; and the higher and looser lands in some interior sections are well adapted to the peach. The Chautauqua district, lying against the eastern end of Lake Erie and now given over very largely to the growing of grapes, is also, no doubt, naturally well suited to peach raising. A conservative estimate would place the lands of western New York which are well adapted to the peach at 60,000 acres.

On the other hand, many of the peach orchards of western New York are planted upon land which is wholly unsuited to them, such as heavy clay soils, or low lands which have very imperfect drainage of both water and air. The ideal peach soil is a deep sand. Upon such lands the trees make a hard growth, the wood matures early, the trees bear young and the fruit is highly colored and flavored. The regions which have become most famous as peach growing centers are those of a sandy formation, as the lands of many parts of the south, of Delaware and New Jersey, and of the "peach belt" on the eastern shore of Lake Michigan. Some of the best peach orchards which I know are upon lands which were once thought to be worthless; and the one shown in Fig. 3 stands on sand which, before the orchard was set, was so loose that it drifted in the wind. Warm sandy lands abound along the Ontario shore, and it is upon them that the peach orchards of that region are giving the best returns. Yet, peaches will thrive upon heavier lands, even upon clay; but they are rarely so productive upon heavy lands unless they are severely headed in. Upon such lands the trees run strongly to wood and they often split down from the weight of foliage alone, when disturbed by wind. The shaley or gravelly slopes about the central New York lakes are generally well adapted to the peach ; and there is a line of morainic hills in western New York which could probably be planted to peaches with eminent success. In interior localities—away from the lakes—it is generally only upon elevated land that peaches thrive. These are lands which are naturally well drained and they escape the late spring frosts which are frequently so disastrous to peach buds in lower places. It is sometimes said that in these interior places trees should not be set upon southern exposures, for in such places the buds are likely to start too early in spring. This is no doubt good advice ; but it should be understood that it may not apply to lands within the influence of bodies of water of considerable size. The areas about the interior lakes which are safe for peaches are usually only a mile or two wide and sometimes they appear to be confined to the farms which lie directly on the shore. The once famous peach district of the eastern shore of Cayuga Lake was confined within a strip three or four miles wide.

Cultivation and fertilizing of the peach orchard.—Having selected his land, the peach grower must look with the greatest care to the cultivation and fertilizing of his orchard. Peach orchards should never be cropped after the third year ; and if they are planted upon sandy lands, which are best adapted to them, and particularly if set less than 20 feet apart, they should never be cropped from the time they are set. The tillage described in Bulletin 72 is the only reasonable treatment for the land in a peach orchard,—very frequent stirring of the surface soil from May until August, and thereafter, perhaps, a green crop, which shall be plowed under the next spring. Never, under any circumstances, seed down a peach orchard ! Never sow it to grain ! Lack of tillage is ruinous, and I am astonished that farmers do not see this fact when bewailing the unprofitableness of their sod-bound, drouth-sick and borer-cursed orchards ! If there is any fruit which should never be neglected, it is the peach ; and this is why careless men do not succeed with it, and why so many of the orchards which I have seen this summer produce only debts and exasperation.

But here comes a difficulty: it is easy to produce an overgrowth upon strong lands. The trees grow to a great size during the first few years, their tops are full of heavy leaves and the foliage holds very late in the fall. These trees generally bear tardily and in some cases they are never very productive of fruit. They run to wood. The winds tear them to pieces. The first trouble lies in the land; it is too strong for the peach. The second trouble may be the too free use of barn manures or other nitrogenous fertilizers, or too late cultivation in the fall. In 1889 I set several varieties of peaches in the University gardens upon soil which had been well manured in previous years, and the land has since been used for garden vegetables which have been well and sometimes even excessively manured with stable manure. The trees have now passed their sixth summer, but not one of them has borne two dozen peaches. Yet they are models of thrift, and the

1. Michigan peach orchard eight years old, with vase-form trees.

large heavy leaves are as green this middle of October as they were in June. Some of them have been entirely ruined by storms, and now the lustiest one of the lot has got the yellows!

I believe that the key-note to the proper fertilizing of peach orchards is potash and phosphoric acid and not nitrogen. Ashes, muriate of potash, bone fertilizers,—these are some of the money-makers for peach trees. Tillage, with green manure crops at the end of the season, can be relied upon to furnish the nitrogen in most instances; and I am not sure but that it is even possible to plow under too much vetch or crimson clover in the course of years. We have been taught all along that nitrogen lies at the foundation of successful agriculture, and this is true; but its greatest benefits, when it is applied artificially, are to be expected upon the annual crops of the farm and garden. It can also be applied advantageously, in some cases, to newly-set fruit plantations. I do not wish to disparage the use of nitrogen, for even in bearing orchards a direct application may sometimes be necessary; but I desire to state what I believe to be a fundamental consideration in orchard culture, that nitrogen can easily be used to excess and that it can generally be obtained by means of tillage and green manure, and also that potash and phosphoric acid need to be annually applied to orchards of bearing age.

2. *Vase-form tree, 10 years old. From life. (Michigan.)*

There are direct experiments which show the effects of various fertilizers upon the peach. These were made upon an extensive base by Dr. E. F. Smith when studying the relation of fertility to peach yellows. The effect of the fertilizers upon the trees was incidental to the subject in hand, but the record* of the investigation is valuable to those who are interested in fertilizing peach lands, as well as those who are studying the yellows. It was found that the nitrogenous manures produce quick results, whilst the potassium and phosphorous generally show their effects more plainly the second or third years. The following citation will show the effect of a nitrogenous fertilizer in stimulating growth and delaying maturity:

Eighty-four trees received Peruvian guano at the rate of 12 lbs. per tree on April 25, 2889. On August 22, 1889, the trees were found to have "made a most astonishing growth. * * The maturity of the season's growth has been retarded and the energy of the trees has gone to the production of an excessive amount of wood and foliage. The latter is now so abundant and so green that the block can be distinguished readily one-half mile away. * * Some of the trees bore a few peaches, and the effect of the guano was to retard maturity. The fruit was also inferior, and some of it withered green instead of ripening, a fact never before observed in this orchard."

Pruning peach trees.—The methods of pruning peach trees are the occasion of much discussion amongst pomologists. The diffences of opinion turn chiefly about three practices,—short trunks with rapidly ascending branches, high trunks with more horizontal branches, and shortening in or heading back the annual growth. Each of these three methods of handling or training peach trees has ardent advocates and pronounced opponents. It is probable that each system has distinct merits for particular cases. I believe that the nature and fertility of the soil are the dominating factors in these opposing methods. A system of pruning which fits the slow growth and hard wood of sandy soils may not be adapted to the rapid growth and heavier tops of trees on strong soils. Fig. 1 shows what I believe to be, in general, the best method of pruning peach trees upon sandy or what may be called peach soils. It is the natural method. The tree is allowed to spread its top at will with no heading in. The foliage is comparatively light and does not place great weight upon the branches, and the trees, upon such lands, do not grow quickly to such great size as upon heavy lands. This method of allowing a tree to make its natural top, is the common one in the Chesapeake peninsula (Fig. 4) and in the Michigan peach belt (Figs. 1, 2, 3). It will be

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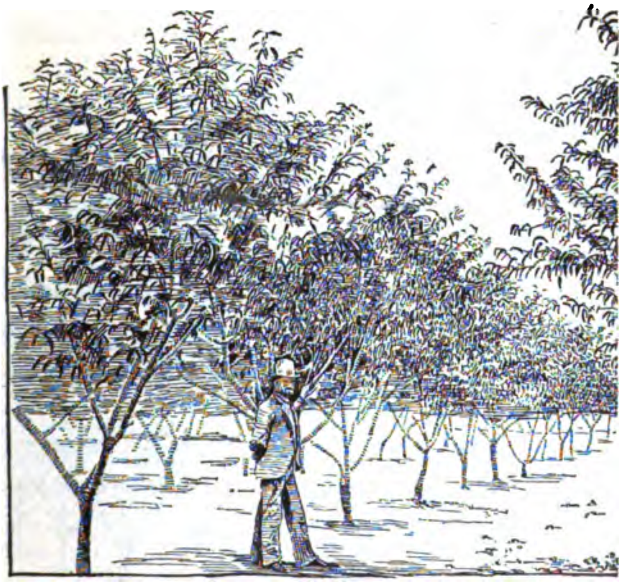
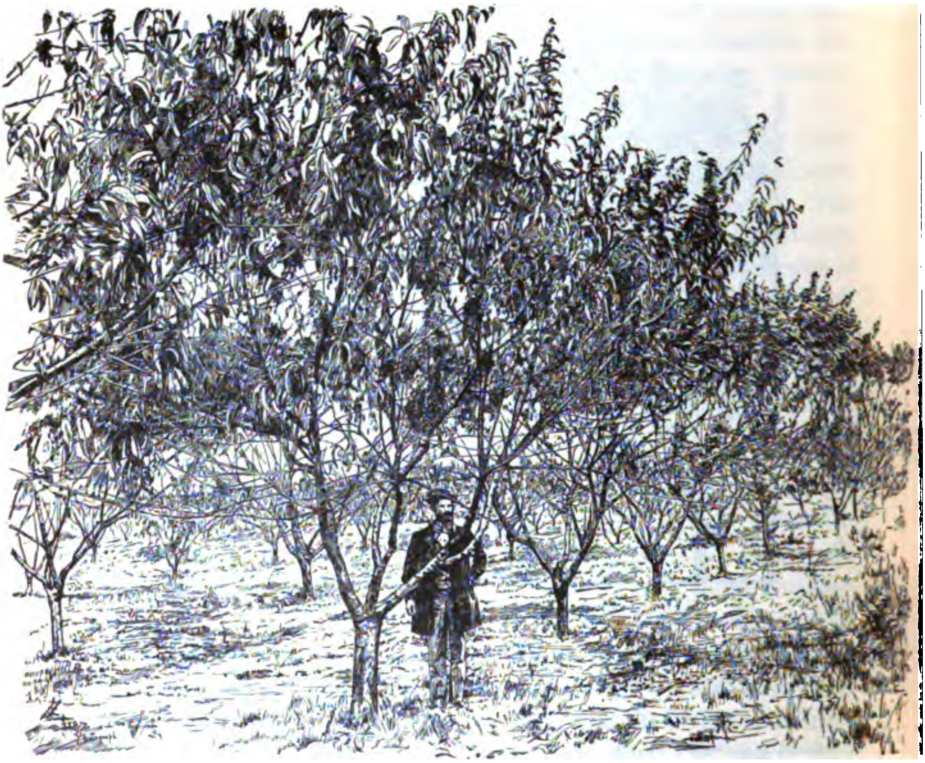
* Experiments with Fertilizers for the Prevention and Cure of Peach Yellows. Bull. 4, Div. Veg. Pathology, Dept. Agric.



3. *Vase-form trees, six years planted.* (*Michigan.*)

observed, also, that the pictures to which I have referred show trees with short trunks and forking branches. It is a prevalent opinion in this state that such trees are more likely to split down with loads of fruit than those which have more horizontal branches (as in Figs. 5 and 6), but I think this to be an error. Of course, some care should be exercised to see that the branches do not start off from the trunk at exactly the same height, thus making a true fork or Y. With this precaution, the crotchy trees are no more likely to split than the others, while they allow of a much better form of top, unless the tree is to be headed in. I have taken particular pains this year to observe the breaking of loaded peach trees, and I find that the limbs much oftener break in two than they split at a crotch, and orchards in which the trees are pruned after the manner of Figs. 1 to 4 have in no case suffered more than others. In fact, the horizontal branches of the high-topped trees often appear to carry a load of fruit with less ease than the more upright branches of the other style of training. This danger of breaking is greatly lessened if the fruit is properly thinned. The low trunk allows of a more open top, and this seems to be an advantage. One is often surprised at the thinness of top in the best peach orchards of Delaware and Michigan. In such tops, the peach should color up better, and it is reasonable to expect less trouble from fungi.



4. *Vase-form trees, six years planted.* (*Maryland.*)*

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* For a contrast of the Michigan and Chesapeake methods, with an account of variations in the sizes of the trees, see *American Garden*, 1890, 20.

Yet there is much to be said, fairly, for the high-topped trees. They are more easy to till and it is quite as easy to pick their fruit; and there is less tendency to make long and sprawling branches as a result of careless pruning. On rich lands, it is perhaps the better method. And here is the chief reason for heading back in this climate,—the necessity of checking the growth and keeping the tree within bounds when it is growing in a strong soil. Whether one shall head in his trees or not, therefore, must depend entirely on circumstances. In sandy peach lands it is generally unnecessary, but it may be a good practice when trees make an over-exuberant growth. This heading in is usually done in the winter, from a third to half the annual growth being removed. It is sometimes done also in the summer, but it is very doubtful if this is a wise practice. Fig. 6 shows an orchard a dozen years old which has been headed in both winter and summer for a number of years. The summer trimming is usually made in June, by clipping off an inch or two of the ends of the tender shoots by means of a sickle or sword.

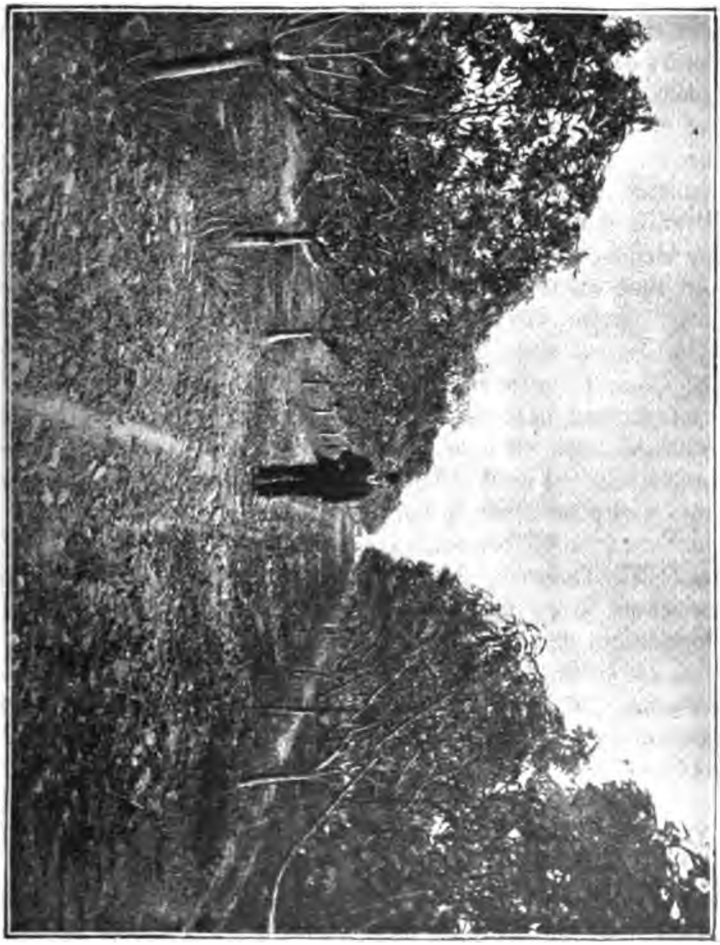
Heading in the branches always makes a thick-topped tree. The Michigan growers usually give much attention to cutting out the small unprofitable wood from the center of the tree. This labor may be greatly increased if heading in is practiced. Many orchards of this state have suffered much during the last two years from twig-blight in these central shoots. This difficulty is discussed farther on (page 379, Fig. 8).

Thinning the fruit.—There is almost universal neglect in thinning the fruit in this state. Every peach grower knows that good fruit cannot be grown upon overloaded trees, and yet he refuses to thin and forthwith blames the market! It should be a rule that no two peaches should stand closer together than five inches of one another. The spray upon the title-page shows, approximately, the distance at which peaches should stand apart. No work of the orchard pays better than this thinning of the fruit, either in the price which the remaining produce brings in the market or in the vital energy which is saved to the tree. Peach trees which are regularly thinned should bear every year, barring injuries from winter or spring frosts. Growers seem to forget that this fruit must all be picked sooner or later, and that the work is more easily done in June or July than in September. The thinning should be delayed until the fruit is the size of the end of one's thumb, for by this time the "June drop" (see p. 383) has occurred, and the peaches can be readily seen and handled.

Marketing the fruit.—But if growers are negligent in thinning the fruit, they are too often positively careless in marketing it. Even in this year of low prices, fancily or nicely packed fruit has brought good prices, wholly independent of its quality. The handsome boxes of California peaches, containing 60 wrapped fruits, have sold from $2.00 to $4.00, and yet they are generally very inferior in quality when they reach our markets. Alongside these peaches, shipped several thousand miles, our peaches have sold for 25 cents to 75 cents a half bushel.

5. Peach orchard with long trunks and round-head training. (Michigan.)

There are several faults with our method of handling peaches. The packages are too large. The fruit is not graded and selected; in fact, it is not well grown. There are often no wooden covers on the baskets, and, as a consequence, that part of the package which should look the best is usually the most jammed and crushed. In observing the markets this summer, I found that quite half the packages were not full when they reached the salesman and the peaches comprising the two or three top layers had chased each other around the basket until they were scarcely recognizable. The peaches had evidently been dumped into the basket and they settled as soon as placed upon the cars. Our method of handling peaches is the very best advertisement of the handsome Pacific coast fruit. In that fruit, every individual peach is sound and perfect; in eastern fruit, the peaches often run through the package and are sold in the liquid state!



6. High-topped trees, shortened in each year. (Geneva, New York.)

Varieties.—Amongst varieties, the Melocoton family is still the most prominent in western New York. The old Red-Cheek Melocoton, from which the family sprung—or at least, varieties under that name—is occasionally seen and recommended, but it is doubtful if the original form of it is now known. This important family of peaches is known by a firm yellow flesh, free stone, red-splashed cheek, and a prominent tip-like projection at the apex. Its chief representatives now-a-days are the Early and Late Crawfords. Some orchards are composed almost entirely of these varieties, particularly in Niagara county, although there are several somewhat differing forms or strains under each name. I am inclined to think that the Crawfords are planted too exclusively and that the time has come for the freer introduction of other sorts. Amongst recent varieties of this type, the Brigdon or Garfield receives most praise in western New York, although Foster and Chair's Choice are popular wherever known. Although the white-fleshed peaches, as a class, are superior in quality to the yellow-fleshed, yet consumers demand the yellow varieties almost exclusively. I have solicited lists of the very best market peaches from well posted men in various parts of western New York, and they are detailed below :

H. S. Anderson, Union Springs, Cayuga Co.—Alexander, Mountain Rose, Early and Late Crawford, Old Mixon Free. To these might be added Wheatland, Wager, Foster and Salway.

S. D. Willard, Geneva, Ontario Co.—Horton's Rivers, Hynes' Surprise, Yellow St. John, Brigdon or Garfield, Red-Cheek Melocoton, Stevens' Rareripe, Willet, Salway. Elberta promises well.

E. Smith & Sons, Geneva.—Atlanta, Yellow St. John, Early Crawford, Brigdon, Potter (new), Lamont (new), Late Crawford, Stevens' Rareripe, Wager.

T. C. Maxwell & Bros., Geneva.—Crosby, Hill's Chili, Elberta, Brigdon or Garfield, Stevens' Rareripe, Red-Cheek Melocoton, and probably a few Early and Late Crawford.

Geo. G. Atwood, Geneva.—Alexander for first early, Early Rivers, Brigdon, Stevens' Rareripe.

C. W. Stuart & Co., Newark, Wayne Co.—Foster, Brigdon, Wheatland, Hill's Chili, Longhurst, Stevens' Rareripe, Wager, Early Rivers, Early York, Early and Late Crawford, Elberta, Hynes' Surprise, Mountain Rose.

C. H. Perkins, Newark.—Early Michigan, Hale, Early and Late Crawford, Foster, Michigan Chili, Barnard, Wheatland.

Geo. C. Snow, Penn Yan, Yates Co.—Early Rivers, Wager, Yellow Alberge, Hill's Chili, Salway.

John F. White, Mt. Morris, Livingston Co.—Elberta, Foster, Early and Late Crawford, Brigdon, Wheatland,—all yellow. Mountain Rose, Stump, Old Mixon Free, for white.

Dewane Bogue, Medina, Orleans Co.—Lolo, Alexander, Early Rivers, Honest John, Early and Late Crawfords, Foster, Hill's Chili, Old Mixon Free, Morris White, Smock.

Julius Harris, Ridgeway, Orleans Co.—Early and Late Crawfords have been the most profitable varieties with me.

H. H. Bickford, Johnson's Creek, Niagara Co.—I should plant chiefly Early and Late Crawfords. Smock is too late for this locality.

W. T. Mann, Barkers, Niagara Co.—Early and Late Crawford, Foster, Reeve's Favorite. Among white varieties I should choose Mountain Rose, Stump, Old Mixon Free, Ward's Late White. Elberta is promising.

F. M. Bradley, Lake Road, Niagara Co.—Early Crawford is our only peach which can be classed as first for market. Yellow St. John is good. Elberta is promising, but is much subject to curl-leaf.

E. M. Moody, Lockport, Niagara Co.—Early Rivers, Mountain Rose, Early and Late Crawford, Smock, Salway.

Peter S. Tower, Youngstown, Niagara Co.—Early and Late Crawford, Reeve's Favorite, Globe, Smock, Old Mixon Free.

Henry Lutts, Youngstown.—Early Rivers, Hynes' Surprise, Yellow St. John, Early Crawford, Old Mixon Free, Reeve's Favorite, Wheatland, Chair's Choice, Late Crawford, Globe, Beer's Smock, Gary's Hold On, Billyer's Late, Salway.

II. ENEMIES AND DISEASES.

Neglect is the most widespread enemy to peach growing in this state. Not only are neglected orchards more liable than others to the attacks of borers and other pests, but they become weak and stunted through starvation. Sod-bound peach orchards are always poor and unprofitable. They have what Professor Roberts calls "timothy yellows," a condition which is far more serious in this state than the true and much-dreaded yellows. The frontispiece shows an orchard which "somehow hain't done well." The trouble is that the owner has tried to raise timothy, sumac, briers and peaches all at the same time. The trees, in the vigor of their youth, bore one crop, "but then they seemed to get the yellows." But it is timothy yellows only. An examination of the orchard, covering many acres, did not reveal a single specimen of the yellows, although nearly all the fruit ripened prematurely and never attained more than half the normal size. But it was as well as trees on one-fourth rations and boarding an army of borers at the same time could be expected to do.

This picture calls to mind the history of the perishing peach industry of the eastern slope of Cayuga Lake; and this history may be taken as a type of the failure of the peach in many parts of the north. "A generation and more ago, peaches were plenty here, but now we cannot grow them." This I hear everywhere,—in Michigan, Ohio, New York and New England. There are many theories to account for this failure. Oftenest, perhaps, it is attributed to change of climate, but we have no proof that any considerable climatic change has occurred, while it seems to be true that the northern peach frontier is holding its own or is even advancing. In New York, the failure is often attributed to yellows, that disease which seems to exist as a vague and indefinable alarm in the minds of the general agricultural population. Yellows is said to have wiped out the peach growing of the Cayuga belt, and it was with much curiosity that I undertook an exploration of this region the present summer. Twenty years ago a million peach trees, it is said, could be seen upon the eastern shore from one point upon the west side, but now there are only a few scattered orchards. Here, then, may be found the secret of this strange falling off of the peach trees in all parts of the country in these recent years.

Slanting towards the lake and pouring into it their drainage of water and cold air, laterally drained by deep ravines and protected from sweeping winds by lines of wood, these Cayuga lands seem to be admirably adapted to the peach. But I found that the region had never been a peach belt, in the sense in which that term will apply to the best part of the Niagara district or to the Lake Michigan belt. In other words, peaches had never been a leading industry there, but the orchards had been planted here and there near the lake as a very minor appendage to the general farming. For a generation or two of trees the insect pests were not common. There were no good markets and the fruit sold as low as twenty-five cents a bushel from the wagon box. In fact, it was grown more for the home supply than with an idea of shipping it to market. Under such conditions, it did not matter if half the crop was wormy or if many trees failed and died each year. Such facts often passed almost unnoticed. The trees bore well, to be sure; but the crop was not measured up in baskets and accounted for in dollars and cents, and under such conditions only the most productive trees left their impress upon the memory. The soils had not undergone such a long system of robbery then as now. When the old orchards wore out, there was no particular incentive to plant more, for there was little money in them. Often the young and energetic men had gone west, there to repeat the history perhaps, and the old people did not care to set orchards. And upon this contracting area, all the borers and other pests which had been bred in the many old orchards now concentrated their energies until they have left scarcely enough trees in some localities upon which to perpetuate their kind. A new country or a new industry is generally free of serious attacks of those insects which follow the crop in older communities. But the foes come in unnoticed and for a time spread unmolestedly, when finally, perhaps almost suddenly, their number becomes so great that they threaten destruction, and the farmer looks on in amazement.

The cause of the failure of these early orchards, therefore, is the gradual dying out of the old system of agriculture and the coming in of special industries. The methods followed with success a generation and more ago are not profitable in the sharper competitions of the present time. At least, there is not the smallest evidence that there is any unusual or insurmountable difficulty in the way of peach growing in this once famous Cayuga region. What yellows exists seems to have come in very recently. Good cultivation and attention to borers and the other difficulties to which peaches are everywhere subject, will enable the people in that region to grow better orchards than were ever grown there in former times. This statement is proved by the partial success which is even now attending those parts of the seven remaining orchards which are receiving as much as indifferent care.

A very brief enumeration of some of the most serious and widespread insect and fungous troubles of the peach in western New York, will serve to call the attention of peach growers to the dangers which threaten them.*

The common *peach tree borer* is unquestionably the most destructive pest of peach trees in this state. It is particularly abundant in neglected orchards. The "worm" or larva is the offspring of a handsome wasp-like moth which flies only during the day and which lays the egg upon the bark during June, July and August, in this latitude. The eggs are usually laid at or near the surface of the ground, although a crotch or other portion of the tree may be selected. The presence of the borer, which works beneath the bark and in the sapwood, is shown by a great exudation of gum. Many operations are advised with a view of preventing the moths from laying eggs, such as washing the trees with soap or other materials, removing the earth from the base of the trees, hilling up the trees, and applying protecting materials like tarred paper or bandages, but all these methods are uncertain and some of them are perhaps wholly ineffective. The only safe course is to dig the borers out in late spring and in fall. This entails some labor, to be sure; but then, it is the price of peaches!

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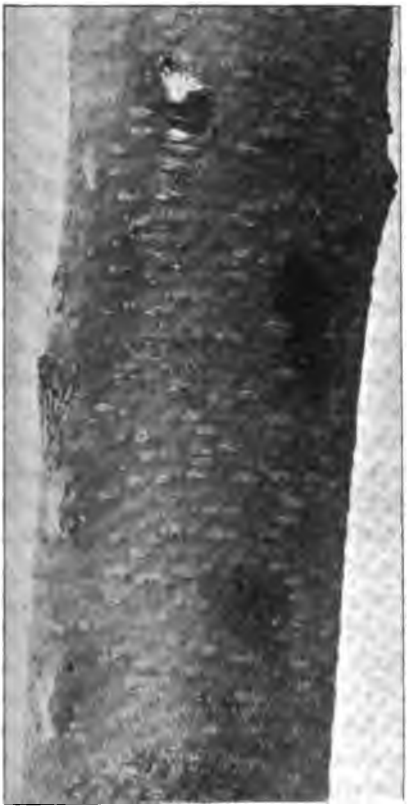
* For a full description of the yellows, see Bulletin 75.

The fruit bark-beetle or *pin-hole borer* (*Scolytus rugulosus*) is coming to be a serious pest in this state. The black beetle is only a tenth of an inch long, and it bores through the bark of the trunk and branches of the plum, peach, apricot, cherry, pear, apple, quince and some ornamental trees. It cuts a clean round hole the size of a large pin, and limbs or trunks which are badly attacked look as if they had received a charge of very fine shot. I have been called to see two peach orchards which were supposed to have the yellows, but most, if not all, the difficulty lay in the punctures of these tiny beetles. A piece of a branch from one orchard is shown natural size in Fig. 7. If one looks closely he sees the minute holes, and below them a lump of gum which has oozed from the punctures. Upon the same farm, dead apricot trees were found to be completely riddled by these pests, the entire bark of the trunk being loosened from the wood by the burrowing of the insects. Here, too, the larvæ or grubs were very abundant, sometimes as many as a dozen being found in a space as large as a dime. In the peach branch (Fig. 7) no larvæ were to be found, and there were rarely any burrowings between the bark and wood. The hole ended in the sapwood and no beetles were



7. *Holes of fruit bark-beetle or pin-hole borer* (*Scolytus rugulosus*).

to be found in late September, when I examined the trees. In the apricots the beetles were abundant at this time. But if the insects themselves were not to be found in the peach, the injury was nevertheless serious, for the bark about older punctures was found to be dead in circular patches an inch or two in diameter.

This pestiferous insect is native to Europe. It was first detected in this country at Elmira, N. Y., in 1877 upon peach trees. It is now widely distributed in eastern America.

There are no specific remedies for this insect. Its life history is not well understood. It is commonly supposed, at least in Europe, that it generally attacks the stunted or least vigorous trees, and that good cultivation and fertilizing are the best general preventives of its injuries. It is said that the more thrifty trees pour out so much sap where punctured, that the young cannot develop. This may have been the case with the peach trees of which I have spoken, but the injury to the tree, as I have said, was nevertheless severe. In some cases, at least, which have come under my observation, the trees seemed to have come into their weak condition wholly through the injuries inflicted by this borer. The eggs are laid in the fall and the beetles probably die thereafter. The new beetle emerges from the tree early in spring and reënters very shortly thereafter. If more than one brood occurs in the season it is not positively known. Forbes has suggested that some adhesive poison spray or wash, applied to the trunk and limbs, may lessen the attacks. All seriously diseased trees and branches should certainly be burned. In Europe, the insect is not generally considered to be very serious. It is probably held in check by parasites. Already one and possibly two parasites have been discovered upon it in this country.*

The *curculio* scarcely needs description. Its presence is everywhere known to be inimical to peach culture, and yet probably two-thirds of the peach orchards of western New York are unmolested breeding grounds of the insect. The beetle begins its work of egg-laying about as soon as the petals fall from the peach flowers, raising up the familiar crescent flap on the young fruit, under which an egg is snugly tucked away. The fruits which are first punctured are likely to drop, but the later ones hang upon the tree and are known by the drops of gum which exude from the punctures. If the egg hatches, the peaches become wormy. It is presumed that the reader is acquainted with the methods of catching the curculio; but it may be said that the operation consists in knocking the insects from the tree by a quick jar or shake, catching them upon a white sheet or in a canvas hopper. The "catcher" most commonly used in western New York (manufactured by J. B. Johnson, Geneva) is a strong cloth hopper mounted upon a wheelbarrow-like frame, and running upon two wheels. The hopper converges into a tin box, into which the curculio roll as they fall upon the hopper. One man wheels the devise, by barrow-like handles, under the tree, then drops the handles and jars the tree; or sometimes two men go with a machine, one wheeling it and the other jarring the trees. There are other devises for catching the cucurlio, but this is the most satisfactory one which I know.

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*For fuller accounts, see Lintner, N. Y. Rep. iv. 103–107; Forbes, Bull. 15, Ill. Exp. Sta., and 17th Rep. State Entomologist of Ill. (with plate).

The black peach aphis is a very destructive insect which is widely distributed in the eastern states, and which has been introduced into Niagara County upon nursery stock.* This insect is particularly malicious because, in the most destructive form, it works upon the roots and is therefore out of sight and largely out of reach. It occasionally feeds upon the herbage, and in that case it can be dislodged by kerosene emulsion. Trees which are suffering from the root aphis stop growing or become stunted, and the foliage becomes yellowish. Affected trees may not grow for several years even under good cultivation, and this condition may pass for yellows. I do not know that this insect is yet widespread in this state, but peach growers should be aware of its existence. Introduced trees should be carefully examined for the aphis before they are set, and if the insect is found, the roots should be dipped in kerosene emulsion or tobacco decoction. If the insect becomes established in the orchard, it can be killed, when upon the roots, by digging in a strong dressing of tobacco dust.

Fruit-rot and twig-blight.—Of the fungous diseases of the peach, one of the most serious in western New York is the twig-blight and fruit-rot (due to *Monilia fructigena*). The rotting of the early peaches on the tree is too familiar to need description, but it is not generally known that this decay is not a normal process and peculiar to the variety, but is caused by a distinct fungous disorder. Very often these same trees which show the fruit-rot, have the young growth blighted, as if attacked by something like pear-blight. This death of the shoots is due to the same fungus which causes the fruit to rot. The decayed peaches sometimes dry up and hang on the tree, and become a prolific source of infection for the coming year. These mummified peaches can be found in orchards all over the state, even, in many cases, a year following the attack. Fig. 8 shows a twig from the center of a neglected peach tree with four mummy peaches a year old, and the fungus has completely killed the entire shoot. Much small dead wood in the center of the tree tops is the result of this monilia, or fruit-rot fungus. The same fungus attacks the cherry and plum.

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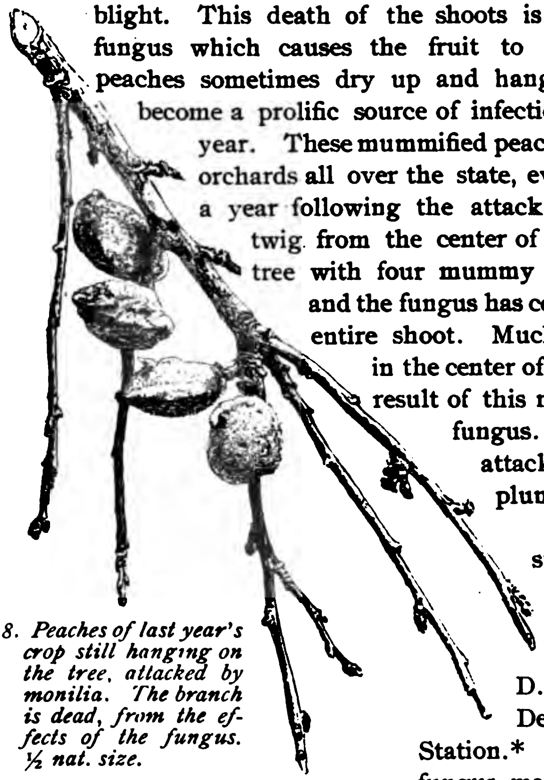
* See Cornell Bull. 49, 1892.



8. *Peaches of last year's crop still hanging on the tree, attacked by monilia. The branch is dead, from the effects of the fungus. ½ nat. size.*

The best economic study of this fungus upon the peach has been made by Professor F. D. Chester, of the Delaware Experiment Station.* He found that the fungus may destroy the flowers in spring, and this injury may pass for the effects of frost. He also found that thorough spraying with copper fungicides greatly reduced the injury. His advice for the treatment of the disease is as follows: 1. Gather and burn all mummified fruit. 2. Early in the spring, before the fruit buds begin to swell, spray the trees with a solution containing 1 lb. of copper sulphate to 25 gals. of water. 3. As soon as the fruit buds just begin to swell, spray the trees with Bordeaux mixture or copper carbonate. Follow this by another spraying before the buds open. 4. As soon as the fruit shall have reached full size and begins to show signs of cólor, make a third application. This should be followed by two or three other applications at close intervals of five or seven days during the ripening period. It will probably not be often necessary to make this late application upon peaches in this state.

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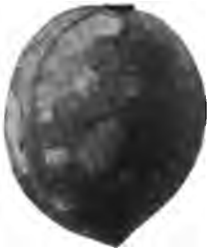
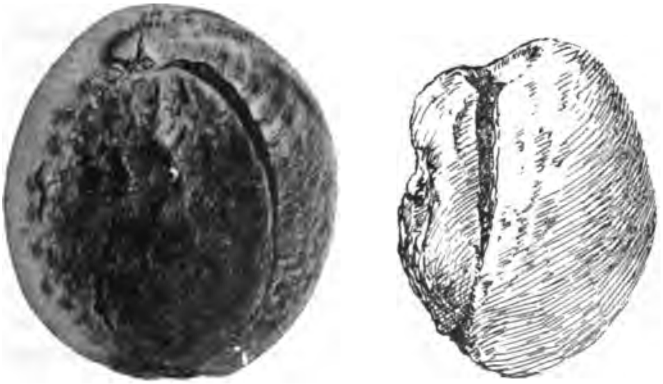
*Bull. XV. Del. Exp. Sta. 10–12; Bull. XIX; Fifth Rep. 53-66.



9. *Mildew patches on young peach.*

The *peach mildew* (*Podosphæra oxyacanthæ*) has been serious in various parts of western New York the past season. In the Niagara belt it has attacked Crawfords, and upon Seneca Lake I have seen a peach known as the Denton almost ruined by it. The fungus generally appears when the peach is very small, as irregular moldy or frost-like patches upon the surface (Fig. 9). Later on. these patches become brown and hard and the peach cracks. The same mildew also attacks the leaves, covering them with a whitish mold-like substance and causing them to become hard and curled. The fungus is common to many plants



10. *Black-spot of peach* (*Hill's Chili*).

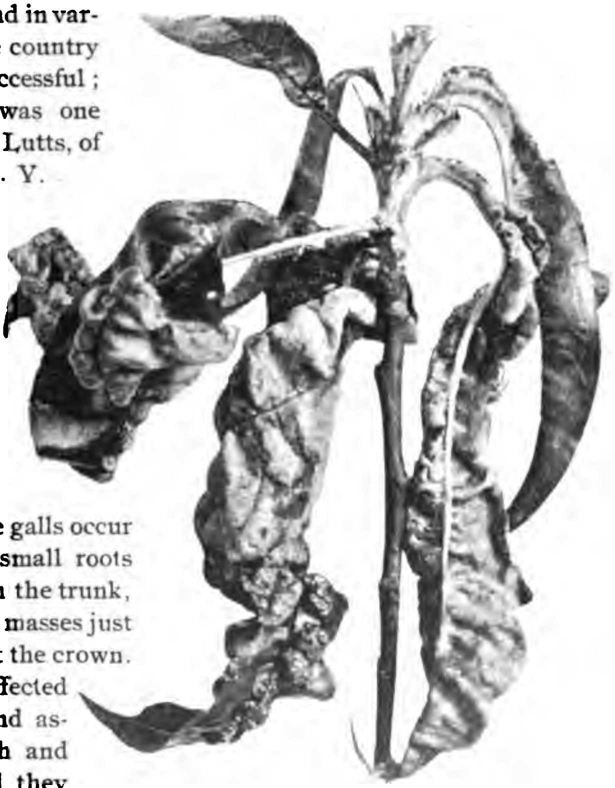
Black-spot.—Another surface fungus which is well known and which has a preference for certain varieties, particularly Hill's Chili, is the black-spot (*Cladosporium carpophilum*). It is usually most serious upon the later varieties. It appears as sooty-black patches of greater or less size, and when the attack is severe the fungus may cover the entire side of the fruit. This side is dwarfed, the flesh becomes hardened, ripens slowly, and deep fissures or cracks appear, sometimes extending through to the pit (Fig. 10). This fungus is usually not sufficiently troublesome in New York to excite general attention, except in certain years and upon particular varieties.

In would seem that the two last diseases should be very easily held in check by a few sprayings with Bordeaux mixture, but the experience of those who have tried it this year has not been reassuring. The chief trouble has been that the fungicide injured the peach foliage. It is well known that peach leaves are very susceptible to any caustic property in spraying mixtures. It is possible that the trouble has been the use of the ferro-cyanide test for making the Bordeaux mixture. This test indicates when sufficient lime has been added to correct the present injurious effects of the sulphate of copper; but in wet seasons—if, in fact, not in all seasons—an extra amount of lime may be needed to neurtalize subsequent changes in the compound. I am strongly of the opinion that the regular formula for Bordeaux mixture—6 lbs. lime, 4 lbs. sulphate of copper—is the safest and best one. The mixture may be diluted to any strength required, but for the peach I should not use less than 40 to 50 gallons of water for the above formula.

The leaf curl has been the subject of more concern amongst New York peach growers during the past few years than any other disease, save the yellows. This trouble is fully discussed in reference to its botanical features in Bulletin 73, p. 324 It certainly has a decided preference for some varieties, particularly those with large, soft and dark-colored leaves. It is also influenced greatly by the season, although it is never wholly absent. A moderate attack does not perceptibly injure trees in full vigor. In many cases, however, the larger part of the leaves fall from the tree in June, and the fruit, deprived of nourishment, may also fall. Leaf curl, the curculio and lack of pollination are the chief causes of the "June drop" of peaches.

There have been few definite experiments in the treatment of the peach curl, but there is reason to believe that one or two very thorough sprayings with sulphate of copper or with Bordeaux mixture before the buds swell, will lessen its spread. A few experiments of this kind in various parts of the country have been successful; amongst these was one made by Henry Lutts, of Youngstown, N. Y.

Root-galls upon the peach, as shown in Fig. 12, have been serious in one orchard in Niagara county, and they are probably widely distributed in the state. These galls occur both upon the small roots several feet from the trunk, and also in large masses just under and about the crown. Trees thus affected stop growing and assume a yellowish and sickly look, and they may be mistaken for trees suffering with the yellows by persons not familiar with that disease. The cause of this disease is wholly unknown. It occurs from the Atlantic to the Pacific, and Atkinson* considers it to be the same as the *Wurzelkropf* of the Ger-



11. Leaf-curl of the peach.

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* *National Nurseryman*, i. 89 (Aug. 1893).

mans. It occurs upon a variety of plants, as raspberries, rose, Marianna plum, pear, apricot and almond; and Wickson and Woodworth report it upon the grape in California. It is said to be very serious upon the Pacific coast. The galls vary in size from that of a pea to twice as large as a man's fist. German writers consider that the disease is due to mechanical injuries of the roots, but this hypothesis is wholly incompatible with the appearance and the spread of the trouble. No investigator has yet been able to discover any insect, fungus or germ to be uniformly associated with the galls. The man in whose orchard I found the galls in Niagara county is convinced that his trees became diseased by growing them in a nursery where infested raspberries were previously grown. The disease is prevalent in our own raspberry plantations at Cornell, and we are able to keep it in check only by pulling up and burning all suspected plants. If berries are affected by this trouble, I should advise destroying the plantation and setting another upon non-infested ground. This disease must not be confounded with the root-knot of the peach and other plants in warm climates and in greenhouses, which is the work of a nematode worm.*

This root-gall has been studied by Professor Woodworth of California,† who gives the following advice: "1. In the orchard the knots should be carefully removed and burned as soon as found, and an antiseptic application made to the tree where the knot has been removed. We would recommed Bordeaux mixture for this purpose. Trees so treated should be examined from time to time for at least a year, and should the knot reappear, it would be best to remove and destroy the whole tree. When a tree is removed, it would be well to delay resetting for a year or two, or to reset with a tree of unsusceptible kind. 2. When setting an orchard, reject all stock affected by the knot. I would prefer to have stock from a nursery known to be entirely free from it. 3. In the nursery, the greatest care should be taken to destroy, by

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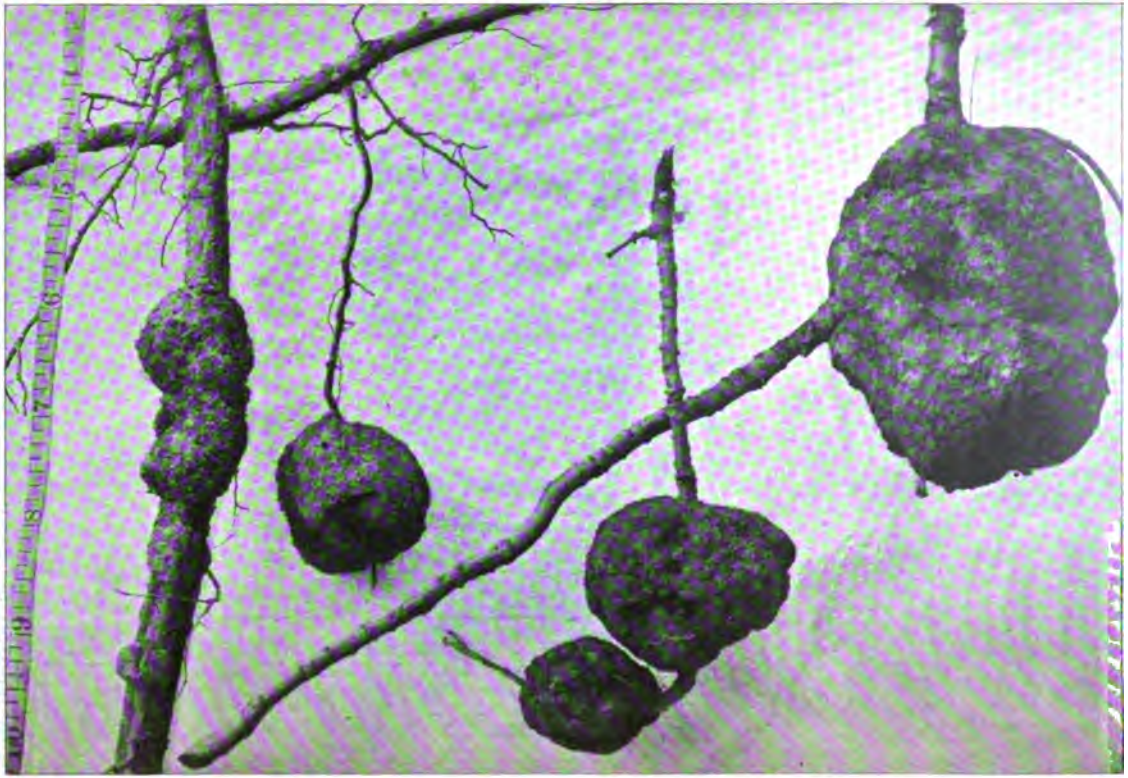
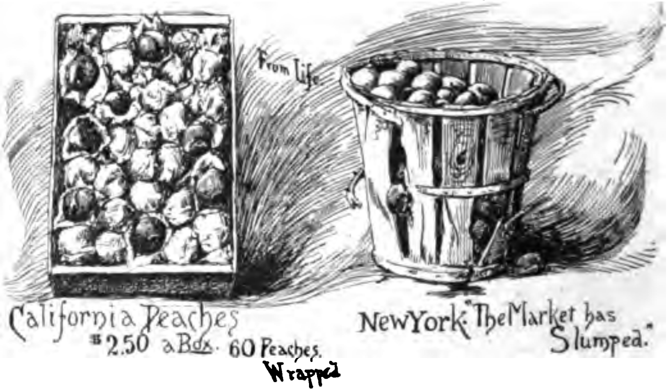
* An illustration and account of the nematode upon winter tomatoes, will be found in our Bulletin 43.

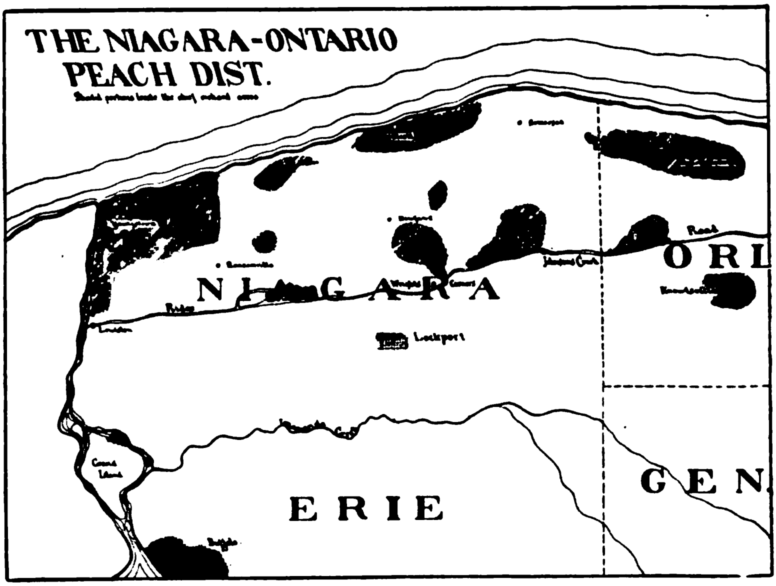
† Bull. 99, Cal. Exp. Sta. (Dec. 1, 1892). See also E. F. Smith, Jour. Mycology, vii. 93; Bull. Torr. Bot. Club, xx. 363.



12. *Root-galls of the peach. An obscure disease affecting the roots of the peach and various other fruits.*

burning, everything showing any evidence of the disease. Fields in which these galls have appeared should be devoted to some other crop for a number of years."


From Life.
California Peaches
$2.50 a Box. 60 Peaches.
Wrapped
New York. "The Market has Slumped."



The shaded portions in the above map show the chief peach-orchard areas in Niagara and Orleans counties

Bulletin 75. **October, 1894.**

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

PEACH YELLOWS.

The wake of the Yellows.

By L. H. BAILEY.

PUBLISHED BY THE UNIVERSITY,
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1894.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.

CORNELL UNIVERSITY, ITHACA, N. Y., Oct. 10, 1894.
THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: This account of the yellows of the peach—probably the most serious and obscure disease of New York orchards—is submitted for publication and distribution in accordance with Chapter 675, Section 87, of the laws of 1894. There has been much inquiry concerning this disease during the present season, and I have endeavored to examine all orchards in western New York from which complaint of yellows has come.

L. H. BAILEY.

NEW YORK YELLOWS AND BLACK-KNOT LAW.

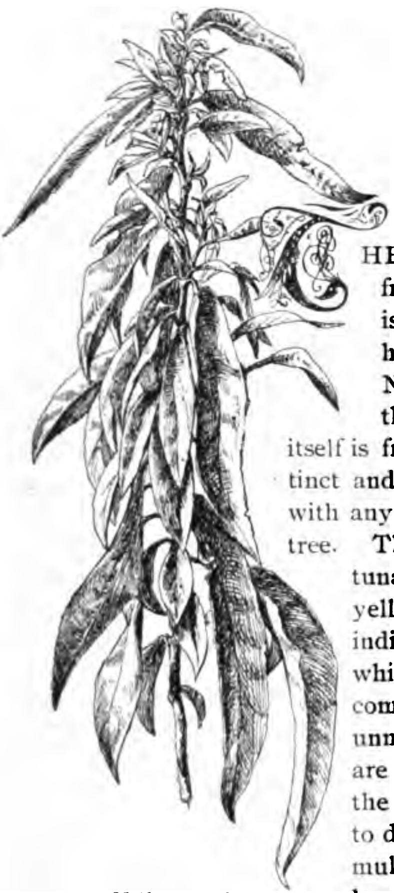
Article 5, Chapter 338, Laws of 1893.

Section 82. **The prevention of disease in fruit trees.**—No person shall knowingly or willfully keep any peach, almond, apricot or nectarine tree affected with a contagious disease known as yellows, or offer for sale or shipment, or sell or ship to others any of the fruit thereof. Nor shall any person knowingly or willfully keep any plum, cherry or other trees infected with the contagious disease or fungus, known as black-knot. Every such tree and the fruit of a tree infected with yellows shall be a public nuisance, and no damages shall be awarded for entering upon premises and destroying such trees and fruit if infected with yellows or for cutting away the diseased part of any tree infected with black-knot or altogether destroying such tree if necessary to suppress such disease, if done in accordance with the provisions of this article. Every person when he becomes aware of the existence of such disease in any tree or fruit owned by him, shall forthwith destroy or cause such tree or fruit to be destroyed or the infected part to be cut away.

§ 83. **Appointment and duties of the agent of the commissioner of agriculture.**—When the commissioner of agriculture knows and has reason to believe that any such contagious disease exists, or that there is good reason to believe it exists, or danger is justly apprehended of its introduction in any town or city in the state, he shall forthwith appoint a competent freeholder of such town or city as his agent, who shall hold office during his pleasure and who shall within ten days after his appointment, file an acceptance of the appointment, with the constitutional oath of office, in the office of the town clerk of the town. Such agent shall on or without complaint, whenever it comes to his notice that either of the diseases known as yellows or black-knot exists or is supposed to exist within the limits of the town or city, proceed without delay to examine the trees or fruit supposed to be infected, and if the disease is found to exist, a distinguishing mark shall be placed upon the diseased trees. If the disease is the black-knot, such distinguishing mark shall be placed on some affected part of the trees, or if in the judgment of such agent any such trees should be entirely destroyed, then the trunk of such tree shall be thoroughly girdled, and thereupon the owner notified personally, or by a written notice signed by such agent and left at his usual place of residence, or if a non-resident by leaving the notice with the person in charge of the trees or fruit, or in whose possession they may be. Such notice shall contain a statement of all the facts found to exist, with an order to effectually remove and destroy by fire or otherwise the trees or parts of trees so marked and designated, within ten days, Sundays excepted, from the day of the service of the notice. In case of fruit so infected, the notice shall require the person in whose possession or control it is found, to immediately destroy the same or cause it to be done.

§ 84. **Proceedings in case of owner's failure to destroy.**—If any person shall refuse or neglect to comply with the order of such agent to remove and destroy trees or parts of trees so marked by him, such agent shall cause such trees or parts of trees to be removed and destroyed forthwith, employing all necessary assistance for that purpose; and such agent or his employes may enter upon any and all premises within the town or city for the purpose of such removal and destruction. Such agent shall be entitled to compensation for his services under this and the preceding sections at a rate of two dollars for each full day spent by him in the discharge of his duties, and the necessary disbursements paid or incurred by him, which with the expense and removal and destruction of any such trees or fruit shall be a town charge.

PEACH YELLOWS.



1. Yellows "tips."

THERE is no disease or difficulty of fruit trees in New York state which is the subject of so much misapprehension as the yellows of the peach. Not only are the origin and course of the trouble obscure, but the disease itself is frequently not recognized as a distinct and fatal malady, but is confounded with any weak or yellow condition of the tree. The name of the disease is unfortunate, since it leads people to regard yellowness as one of the first and indisputable symptoms of yellows, while, in fact, the disease may become well seated and may show its unmistakable symptoms in trees which are dark green and robust. It is for the purpose of enabling fruit growers to distinguish the true yellows from a multitude of other ailments that I have prepared the present report.

NOTE.—Those who desire to make a more particular study of peach yellows, should consult the following publications of Dr. Erwin F. Smith, who is the recognized authority upon the subject:

Peach Yellows: A Preliminary Report. Bull. 9, Div. of Botany, Dept. Agric. 1888.

Additional Evidence on the Communicability of Peach Yellows and Peach Rosette. Bull. 1, Div. Veg. Pathology, Dept. Agric. 1891.

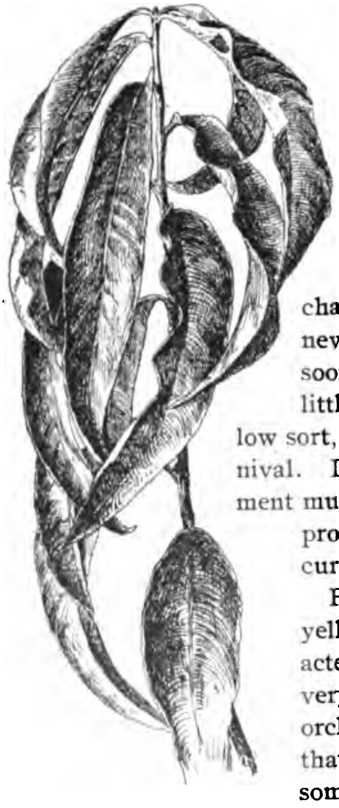
The Chemistry of Peach Yellows. I and II. Proc. Amer. Pomol. Soc. 1889 and 1891.

Peach Yellows. Report of State Hort. Assoc. Penn., 1893.

Experiments with Fertilizers for the Prevention and Cure of Peach Yellows. Bull. 4, Div. Veg. Pathology, Dept. Agric. 1893.

Peach Yellows and Peach Rosette. Farmers' Bull. 17, Dept. Agric. 1894.

It should first be said that the yellows is generally spread throughout the state. I have made a careful study of the peach industry of western New York during the present season, and I have run upon the yellows in almost every region which I have visited. It is particularly bad in Niagara county, which is the leading peach section of the state. It also occurs along the central lakes, in the Hudson River valley, and, no doubt, wherever peaches are grown to any extent. Yet the disease is not also so serious in certain regions as people have supposed it to be. I have visited orchards which were said to be dying with yellows, and have found only borers and that sublime neglect which characterizes so many peach orchards of the state. Orchards which are never cultivated or pruned or fertilized, soon become sad-looking objects, making little growth and that of a feeble and yellow sort, and the borers hold unmolested carnival. In such cases, the first remedial treatment must be applied to the owner, for unprofitable or diseased orchards cannot cure themselves.



2. *Healthy terminal shoot.*

Fruit growers should know that peach yellows is a distinct disease, with characteristic symptoms, that it attacks the very best and strongest trees of the orchards as well as the weak ones, and that its end is always fatal. I have sometimes thought that the most vigorous trees are most liable to attack. It is certain that orchards in otherwise prime condition may be completely swept away with the yellows.

The most lamentable circumstance connected with the yellows in this state is the legal complication which arose in Niagara County* in 1889, when an attempt was first made to enforce the law which demands that yellows shall be eradicated. Commissioners were duly appointed and they proceeded with their duty of examining orchards and marking diseased trees. There was little general or popular knowledge of the disease, and the commissioners consequently met with opposition. It was charged that they marked trees which were not diseased. Whether this is true or not, it transpired that a certain peach grower refused to cut the trees which the commissioners had designated. Under the law, the officers cut the trees, but the owner refused to pay costs, and the people brought suit against him for misdemeanor. The trial was long and stubbornly fought. The trees which had been cut were destroyed, and there was therefore no evidence to prove that the trees in question had had the yellows. Much testimony of a general nature was admitted by the court as a matter of general interest and education, but the question which went to the jury was the specific one concerning the defendant's trees. The jury disagreed, and the defendant was acquitted. The result was regarded as a great victory by those who opposed the operation of the law; and it has had the effect of discouraging further efforts towards its enforcement in that county. The outcome has been most disastrous. The yellows is now widespread throughout the region which is naturally the best peach section of western New York, and the dying and neglected orchards of careless peach growers are a constant menace to the peach industry. It will never be known, beyond the parties immediately concerned, whether the trees over which the suit occurred had the yellows; but I have this year visited the neighborhood which was the scene of the conflict and I found orchards ruined by the disease. Any law is impotent unless it is sustained and enforced by public sentiment. Every farmer should understand that peach yellows is a fatal and communicable disease, and that it is, therefore, amenable to control by the police powers of the commonwealth. Like pleuro-pneumonia and tuberculosis, it is a public nuisance.

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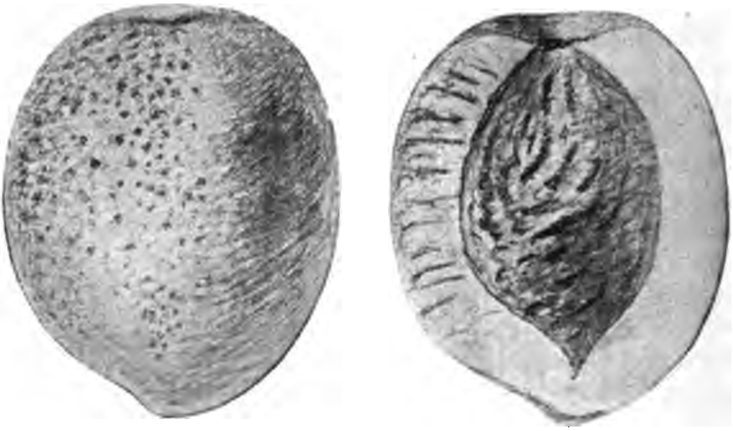
* Annals of Hort. 1889, 70.

When the yellows attacks a bearing tree, the first sign of its presence is usually in the fruit. The one unmistakable symptom in the fruit is the presence of bright red spots which may be likened to measle blotches, and the flesh is also more or less marked by red spots and streaks which often run through to the pit. When the attack is slight, these red streaks in the flesh may be faint or even almost absent, but the external spots are characteristic. The illustration (Fig. 3) shows a diseased peach. In addition to these marks upon the peach, the fruit generally ripens prematurely, although I have seen cases in which the spots were present upon fruit ripening in its normal season. On the other hand, yellows peaches sometimes ripen six weeks in advance of their season, particularly after the disease has run a year or two. Mere prematureness is not an indication of yellows. I have repeatedly been shown trees, during the past season, which were said to have yellows because the fruit ripened prematurely, but which were suffering only from borers, neglect or drouth. These peaches lacked entirely the bright red spots of the yellows. Yellows peaches are usually poor in quality, particularly in sweetness ; yet when the attack is recent and the fruit is not markedly premature, the quality may not seriously suffer. In the second year of the visible attack, however, the quality of the fruit is perceptibly low.

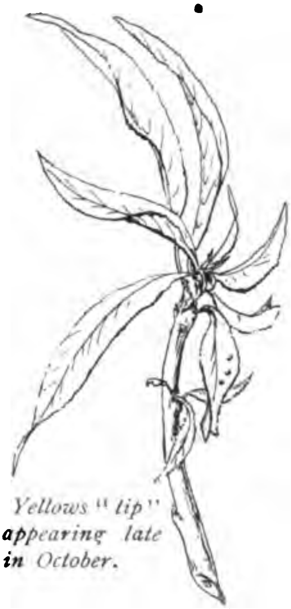


3. *Yellows peach.*

Yellows generally appears at first upon a part of the tree only. Sometimes only one or two peaches may show any indications of the disease, and the tree may appear to be perfectly healthy.

Whether the branch upon which these peaches are borne is removed or not, the disease will be found the following year to have spread, involving more branches and possibly the entire tree.

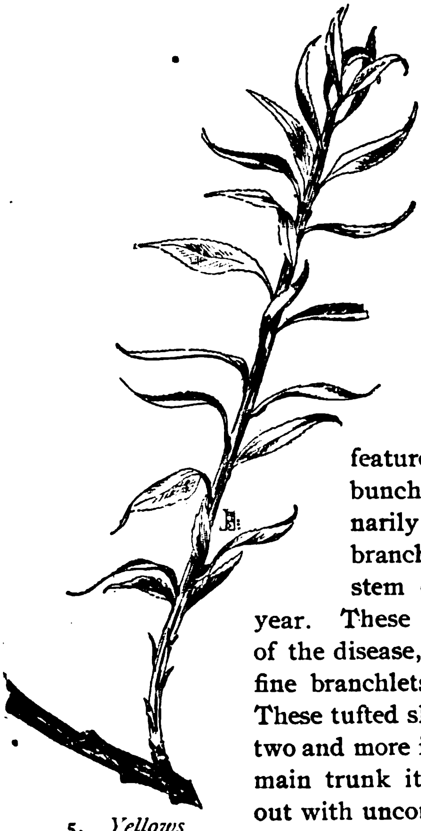
The second characteristic symptom of yellows—or the first in trees not in fruit—is the appearing of short, yellowish, unbranched shoots or "tips" upon or near the ends of the healthy branches. These sometimes appear upon the ends of lusty watersprouts, and in such cases I have seen them well developed even when the fruit showed no signs of disease. The tail-piece (page 408) is such a watersprout tip. These little shoots spring from buds of the season, which under normal conditions, would not have pushed into growth until the following spring. These shoots may appear as early as July or even June, but in the early stages of the disease they are usually not seen until late summer or fall. In this state, I see them first, as a rule, in September. When they appear at this date, they rarely grow more than three or four inches long. The leaves upon these yellows "tips" are small and narrow, yellowish, and they usually stand out stiffly at nearly right angles to the stem, contrasting strongly with the drooping healthy leaves below them. The tail-piece, on page 408, shows a yellows tip of Crawford, photographed late in September. Sometimes several of the uppermost buds upon a twig will start out into this short stiff tip-like growth. This feature is shown in Fig. 1. Contrast this shoot with the healthy twig, taken from the same tree, shown in figure 2. These tips sometimes appear late in fall after most of the leaves have fallen. The winter buds simply expand their sickly leaves and the stem may make no growth. Fig. 4 shows such tip, appearing late in October. Occasionally



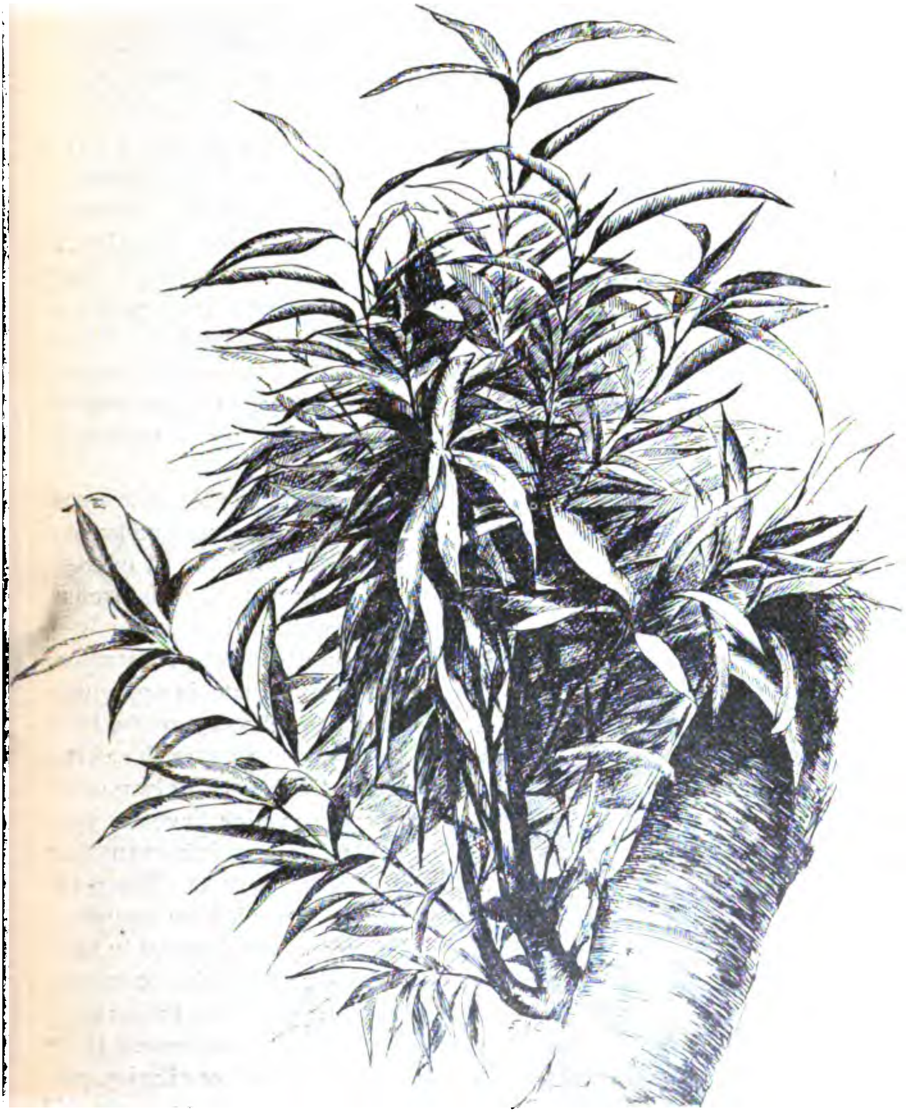
4. *Yellows "tip" appearing late in October.*

one may see these tips expanding prematurely in earliest spring. Frequently, in this state, these tips are so little pronounced, even upon trees badly diseased, that they are likely to pass unnoticed; and in such cases one must rely very largely upon the fruit for a diagnosis of the disease. In rare instances, the blossom buds upon diseased shoots may expand in the fall.

The third symptom of yellows is the appearing of abnormal shoots along the larger branches or even upon the trunks. These yellows shoots generally appear earlier in the season than the tips, and may make considerable growth. They are marked by short and narrow leaves which stand at nearly right angles to the stem, as seen in Fig. 5. They rarely grow more than a foot in length in this state. But the most striking form of this third feature of yellows symptoms, is the bunchy growth shown in Fig. 6. Ordinarily a healthy peach shoot does not branch as it grows, but makes a straight stem one year, and branches the next year. These yellows shoots, in confirmed cases of the disease, may branch into several or many fine branchlets the very year in which they start. These tufted shoots may spring from old branches two and more inches in diameter, or even from the main trunk itself (Fig. 6). They often spring out with uncommon luxuriance from the stumps of trees which have been cut with yellows. These bunchy growths rarely appear before the third year of the disease in this state, and in the great majority of cases of yellows which I have seen in New York they are wholly absent, even in the final stages. They appear to be less abundant in dry years. It is the first two symptoms—the red-spotted fruit and the



5. *Yellows shoot.*



6. *Yellows tuft—½ nat. size.*

"tips"—which must generally be relied upon in this state for the diagnosis of the yellows; and even the tips, as I have said, may be so little developed as not to attract attention. The one unmistakable and invariable symptom of the peach yellows is in the fruit.

The fourth and final stage of the disease is that in which the entire tree assumes the narrow, yellow or reddish and rigid leaves, and in this condition the tree is not readily distinguished, by the novice, from trees which are much debilitated by borers or neglect. The length of time from the onset of the disease at which this final stage and the death of the tree occur, is not a fixed period. It is undoubtedly modified by many conditions. From the time when the first symptoms appear, it is not less than three years before death occurs, and it is oftener five or six years. But death is sure to come sooner or later, for there is no indisputable case on record of yellows having been cured.

There is abundant proof that yellows is communicable from tree to tree. Sooner or later, every peach tree in any community in which the disease appears, may be expected to die from it, unless rigorous measures are taken to keep it in check. The disease is so insidious and often so slow in its progress that it usually becomes thoroughly established in a community before it attracts attention, and peach growers generally procrastinate in applying restrictive measures. It is unknown how the yellows spreads, but it is not through the soil, for young trees may be set with safety where yellows trees have been removed. Neither is it always, if ever, conveyed from flower to flower, for trees which have not yet blossomed often contract the disease. It does not inhere in the roots, for trees grafted upon plum stocks contract it. There is every reason to believe, also, that it is not carried on pruning tools. The means by which the disease spreads will probably not be known until the cause of the trouble is ascertained. Respecting this cause, there has been distinct progress in eliminating almost every origin which has been ascribed for the disease. It is known that yellows is not due to conditions of soil or climate, to mechanical injuries, to over-bearing or starvation, to methods of propagating, pruning or cultivating, to insects or fungi, and Dr. Erwin F. Smith, of the national Department of Agriculture, who is the recognized authority upon the disease, now declares that "it is almost certainly not a bacterial disease." Dr. Smith thinks that the disease is "nearest allied to that phenomenon in plants known as variegation." It has been long known that most variegation is an abnormal state or condition and that it can sometimes be communicated to normal plants by means of budding; but it is difficult to conceive of any means by which such condition can become contagious without the presence of germs.

But there is every reason to expect that when the cause of the yellows shall have been discovered, the treatment will remain the same as now,—extermination of the affected trees. This seems to follow, from the fact that when the first symptoms of yellows are discovered upon any branch, the entire tree is diseased. Numerous critical experiments have been made to determine this fact, by cutting off the diseased limb. In every case the remainder of the tree has shown yellows, usually the following year, but sometimes not until the second year. And these results are exactly in line with the experience of all peach growers who have had to deal with yellows. It will also be necessary to exercise the same caution in the choice of buds for propagation, for it is known that a bud from a yellows tree—even from that part of a tree not yet visibly affected—will make a yellows tree and will communicate the disease to the stock. Premature yellows peaches rarely have good seeds, but the pits from the apparently healthy portions of diseased trees may be expected to convey the disease to the offspring.

So far as known, peach yellows, like pear blight and plum knot, is a purely American disease, and has not been introduced into other countries. It is generally distributed in peach sections east of the Mississippi river and north of North Carolina and Tennessee. It first attracted attention about a hundred years ago in the neighborhood of Philadelphia, whence it appears to have spread throughout the country. It was probably introduced into the peach region of southwestern Michigan—where it appeared nearly thirty years ago—by diseased eastern stock. As near as I can learn, it appeared in Niagara county, New York, about twenty years ago. The disease seems to prefer the peach, but it is known to attack the nectarine, almond, apricot and Japanese plums.

The only check for the spread of the yellows is extermination of the affected trees, and I doubt if a better method will ever be discovered. There is much difference of opinion as to when and how the trees should be removed. If but a single branch is affected and the disease shows only in the fruit, it is considered to be safe to burn the diseased branch and fruit at once, but to allow the remainder of the tree to ripen its crop. As soon as this crop is off, pull up and burn the tree, root and branch. If the disease appears upon a tree not in fruit—even if upon but a single branch of it—I should forthwith, as soon as the disease was discovered, pull out the tree and burn it. There is a tendency in this state to allow the trees to stand until fall work is done or until some other convenient season shall arrive; but growers who practice such methods are not long troubled with peach orchards.

This method of immediate extermination has been proved time and again to be completely effective in holding the disease at bay. The experience of the Michigan peach growers is often cited, and it is undoubtedly the best illustration extant of the effectiveness of timely and coöperative effort. The oldest commercial peach region of Michigan is that lying in Berrien county, in the southwestern corner of the state. Here the yellows first appeared. At that time, the disease was little understood, and growers temporized with it, and tried to cure it. As a result, the entire peach industry was wiped out, and small fruits, grapes, and truck-gardening took its place. Lying twenty-five miles north of this St. Joseph region and then separated from it by several miles of wild country, is the South Haven region. In this second region the disease finally appeared and destroyed a number of orchards, but the people, profiting by the disastrous experience of their neighbors upon the south, soon began a vigorous war of extermination against it. The local pomological society united the leading peach growers in the crusade, and the state legislature was prevailed upon to pass a law providing for the legal exercise of police powers upon the part of townships. This was probably the first American law aimed at a disease of plants, and from it have sprung the perfected laws of recent years relating to yellows, black-knot and other diseases and insect pests. There were some growers of influence who resisted the law, but upon the whole the community was united in the one determination to check-mate the yellows. For a time the disease seemed to over-ride all opposition, but it was finally checked, and it has not seriously interfered with the peach industry for the last dozen years. It is still present, however, and in certain seasons it breaks out with renewed vigor, but these recurrences are as vigorously met by the growers, and the disease again subsides. These years of renewed activity of the yellows are apt to follow years of comparative immunity, largely because of the less careful scrutiny by the yellows officers in the years of freedom from the disease. This determined fight against a common enemy has knit the peach-growing community together and has developed a local pride which is entirely absent in the peach sections of New York state. Public sentiment demands that no yellows peaches shall be shipped. A sign hangs in the warehouse at the port with this legend:

"All peaches left here infected with yellows will be destroyed and the owner prosecuted."

This sentiment is unknown to the New York peach growers, as a body. Everywhere I see yellows peaches on sale. These peaches are not injurious to health, so far as known, but they are inferior in quality, and the Michigan people have learned that the sale of them hurts their reputation and market. But the New York growers, as a rule, have not yet got beyond the point of asking if the diseased peaches are unwholesome, and have not risen to the plane of demanding that only good fruit, like pure milk, shall be allowed to make their reputation upon the market. And the clause of the law forbidding the sale of yellows peaches is practically a dead letter.

The success of the Michigan growers in stemming the invasion of yellows has revived confidence at St. Joseph, and that region is again growing peaches with its earlier eminent success. I do not expect equal success in eradicating yellows in this state, from the fact that the peach industry is nowhere extensive enough to make it the one absorbing interest of the community. As soon as it becomes the chief occupation of any region, the people will combine in self-interest to hold it in check. Yet the individual grower, if affected orchards do not adjoin his own, can keep the yellows at bay with a loss of only a few trees each year. There are such growers in Niagara county and other parts of the state, and their success should reassure all those who despair at the inroads of the yellows. But it must be remembered that the most painstaking vigilance is required to keep orchards healthy, and the best remedy for the evil will be found in the rigid enforcement of the law. No amount of arguing will stop the yellows. Fire is the only recourse.

Most of the laws aimed against peach yellows have serious defects. The most glaring of these is the fact that the owner of the trees has no appeal from the decision of the commissioners who are appointed to examine the orchards. There is always danger that incompetent or careless men may be appointed to the commissionerships, whose rulings may not be acceptable even to the best disposed citizens. The disease is so obscure that only the most careful and judicious men should be selected to diagnose it, and, even at the best, there are men in almost every community who object to the destruction of their trees. Lack of confidence in the commissioners has been the most serious obstacle to the execution of the New York law, and it was at the bottom of the suit which occurred in Niagara county in 1889. There is a feeling, also, that the work of the commissioners in cutting trees is the invasion of a man's property without due process of law. All this is remedied in the Connecticut law—which is the best of all yellows laws,—for the owner may appeal from the findings of the commissioner to the State board of agriculture, which "shall appoint a committee of three experts, which committee shall not include the person who, acting as commissioner or deputy, ordered such tree or fruit destroyed, and the decision of such committee shall be final."

Another difficulty with the laws is the danger that political considerations will prevail in the appointment of the commissioners. This danger is imminent whenever the commissioners are appointed by any officer or board which is itself a political appointment or creation. The difficulty can be averted only when the commissioners are created by a non-political board or office, as in Connecticut.

Other hindrances against the efficient operation of yellows laws are the inadequate pay given the commissioners—often rendering the appointment of thoroughly competent men impossible—and the lack of any general office or officer who shall keep records of the spread and control of the disease. This latter omission is serious, from the fact that it is only by a study of careful statistics extending over a series of years that the progress of the disease can be accurately known and the effectiveness of remedial laws adequately measured. This important statistical feature has been embodied in the Connecticut law, and the yellows commissioner reports that in the year 1893 official examinations were made of 283,782 trees, of which 28,647 were condemned.

The full text of the Connecticut yellows law is as follows:

SECTION 1. The State Board of Agriculture shall, within thirty days from the passage of this act, appoint a commissioner on peach yellows, to hold office during the pleasure of said board. Said commissioner may, with the approval of said board and under the provisions of this act, adopt and carry out such plans as may be deemed necessary for the eradication of the disease, common to peach trees, known as peach yellows.

SEC. 2. At all joint meetings of said board and said commissioner, for the purpose of conference, the commissioner shall receive pay from the board for his expenses only. Said commissioner may, with the approval of said board, appoint one or more deputies in each county; and when employed in the performance of duties imposed by this act, said commissioner and his deputies shall receive from the state, upon presentation to the comptroller, of bills duly sworn to, audited by the auditing committee of the board of agriculture, and approved by the Governor, five dollars per day and their expenses.

SEC. 3. Any peach, almond, apricot, or nectarine tree diseased by the yellows, and all fruit from any such diseased tree, is hereby declared a public nuisance, and it shall be the duty of said commissioner or any deputy, under such regulations as the State board of agriculture may adopt or approve of, to order such trees or such fruit destroyed, and upon the failure of the owner to obey such order, to destroy such trees or fruit, and no damage shall be paid to such owner on account of such destruction.

SEC. 4. Any person may, when ordered to destroy any tree or fruit condemned by the said commissioner or deputy, appeal to the State board of agriculture, and said board shall appoint a committee of three experts, which committee shall not include the person who, acting as commissioner or deputy, ordered such tree or fruit destroyed, and the decision of such committee shall be final.

SEC. 5. Any person who shall, while such an appeal is pending, sell any tree from a nursery where there are found to be diseased trees, or any fruit from such tree; or who shall, without such appeal, or after such final decision, refuse to destroy such tree or fruit, shall be fined not less than one hundred or more than five hundred dollars.

SEC. 6. Any person that shall knowingly buy, for the purpose of selling, or shall sell or offer for sale, any fruit from such diseased trees, shall be fined not less than ten nor more than one hundred dollars.

SEC. 7. For the purpose of investigation or for the purpose of destroying trees or fruit known to be diseased, the said commissioners and his deputies may enter any premises; and any person who shall prevent or attempt to prevent such entry shall be punished by a fine of not less than ten or more than one hundred dollars, or imprisoned in a common jail not less than ten nor more than sixty days, or both.

SEC. 8. Prosecutions for violation of this act may be brought before justices of the peace, or any city, borough, town police, or common pleas court having criminal jurisdiction, by any prosecuting officer, or by the commissioner on peach yellows, or any of his deputies, and for such purpose said commissioner and his deputies shall have all the power of grand jurors.

SEC. 9. This act shall take effect upon its passage.

YELLOWS BREVITIES.

Yellows is a distinct disease. It attacks peach trees of all ages and in all conditions of vigor, seeming to have a preference for those which are thrifty. It is incurable, and its termination is always fatal.

The disease sometimes attacks the almond, apricot, and Japanese plum.

Yellows has been recognized for about a century. It is peculiar to North America, and is generally distributed north of the Carolinas and east of the Mississippi.

It is communicable from tree to tree. The means of communication is unknown, but it is not spread through the soil, it does not originate in the roots, it is evidently not conveyed from flower to flower, and it is probably not transferred by means of pruning tools.

The cause of the disease is wholly unknown. Almost every ascribed caused has been disproved upon careful investigation.

It has no uniform preference for varieties, soils, climate, nor methods of propagation or cultivation.

No fertilization of the soil will cure the disease or check its spread.

The one unmistakable symptom of yellows is the red-spotted character of the fruit. The flesh is commonly marked by red lines or splashes beneath the spots. These peaches generally ripen prematurely, and in the second year they are usually smaller and often more fuzzy than the normal fruit. The second symptom to appear—or the first in trees not in fruit—is the "tip" growth. This is a short growth starting from the upper or terminal buds, usually late in the season, and is characterized by narrow stiff yellowish small leaves which stand at nearly right angles to the shoot. Sometimes these tips appear late in autumn, after the leaves have fallen, or in spring before normal growth begins. They are often first seen upon the ends of watersprouts. This "tip" growth is sometimes little pronounced, and then only a practiced eye will detect it.

The third mark of the disease is the pushing out of slender stiff-leaved yellowish shoots from the body of the tree or the sides of the large limbs. In pronounced cases, or when the tree is about to die, these shoots may branch into close bunchy tufts. These symptoms are frequently wholly absent in this state throughout the entire course of the disease.

In its final stage, the disease is marked by small and slender growth of all new wood, small, narrow, yellow or reddish foliage, and occasionally by a great profusion of slender and branchy growths in the center of the tree.

As a rule, yellows trees die in five or six years from the first visible attack.

The yellow and stunted condition following neglect or the work of borers—both of the common borer and the pin-hole borer—is often mistaken for yellows.

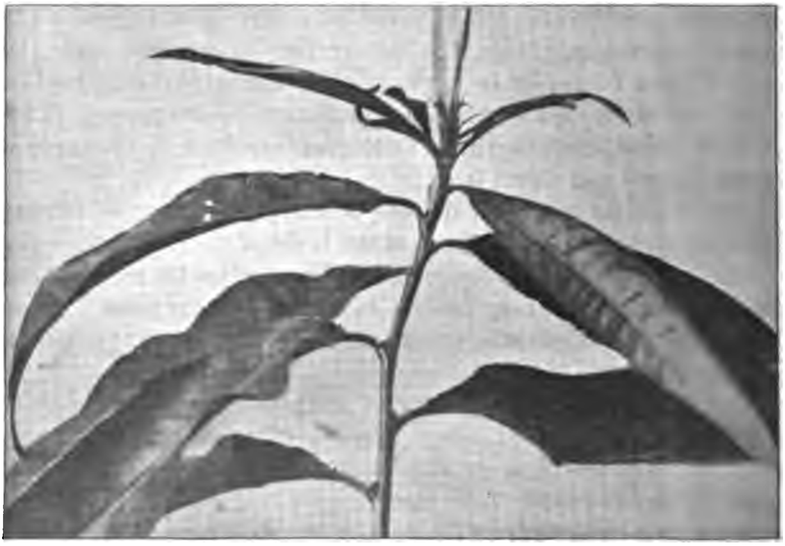
Extermination of all affected trees—root and branch—is the only method of keeping the disease at bay. This work should be prosecuted vigorously and systematically and with the full support of the entire community.

Trees may be set in the very places from which yellows trees have just been removed, with entire safety.

The disease is readily communicated to nursery stock by affected buds, even by buds from those branches of affected trees which do not yet show any signs of the yellows.

Pits from affected trees—when viable—may be expected to propagate the disease.

L. H. BAILEY.



Yellows "tip" on a watersprout.

Bulletin 76. November, 1894.
Cornell University Agricultural Experiment Station.
HORTICULTURAL DIVISION.

SOME GRAPE TROUBLES OF WESTERN NEW YORK.

By E. G. LODEMAN.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.

CORNELL UNIVERSITY, ITHACA, N. Y., Nov. 1, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: The following account of some of the difficulties in the way of grape growers in the Fifth Judicial Department of New York, is submitted as a bulletin to be published under the provisions of Section 87, Chapter 675, of the laws of 1894.

The trouble known as "rattles" has been very serious the past season, particularly in the Chautauqua region. We have made a thorough study of it in the field, and the following paper is believed to contain the best information obtainable concerning it. Definite and perhaps prolonged experiment upon an extended base is needed, however, to discover the exact cause and to suggest specific remedies.

Grape growing is one of the leading industries of the state, and its area is increasing. The extent and distribution of the acreage in western New York are approximately as follows:

Chautauqua region,	26,000 acres.
Canandaigua "	5,000 "
Keuka "	10,000 "
Seneca "	6,000 "
Cayuga "	3,500 "
Scattering,	7,500 "
Total,	58,000 acres.

L. H. BAILEY.

SOME GRAPE TROUBLES OF WESTERN NEW YORK, 1894.

SYNOPSIS.

- PART I. IN CHAUTAUQUA COUNTY (pages 413 to 443).
  - A. Shelling or Rattling, page 413.
    - Similar European Diseases :
      - Apoplexie or Folletage, page 420.
      - Rougeot, page 421.
    - Ascribed causes of shelling, page 421.
      - Group I. Injuries caused by parasites, page 423.
      - Group II. Improper conditions of the vine, page 425.
      - Group III. Conditions of the soil, page 427.
      - Group IV. Conditions of the atmosphere, page 435.
    - Remedies, page 435.
    - Opinions of Growers, page 436.
  - B. Powdery Mildew, page 441.
  - C. Anthracnose, page 442.
- PART II. IN CENTRAL NEW YORK (pages 444 to 449).
  - D. Black-rot, page 444.
  - E. Brown-rot, Gray-rot, page 446.
  - F. Ripe-rot, page 448.
- PART III. MACHINERY FOR SPRAYING, FORMULAS (pages 450 to 452).
  - Summary, page 452.

PART I—IN CHAUTAUQUA COUNTY.

A. SHELLING OR RATTLING (pages 413 to 440).

Many grape growers of Chautauqua county have this year lost a considerable portion of their grapes on account of the berries dropping to the ground before they were fully mature. This condition is commonly known as the "shelling" or the "rattling" of the grapes. Its unusual prevalence and the severity of the attacks in some vineyards have caused the vineyardists much uneasiness regarding the losses caused and the possible extent to which the trouble may affect the vines in the future. During the past fall it has appeared more or less seriously throughout the region of the Chautauqua grape belt, and some portions of central New York have not entirely escaped its presence.

The trouble is not a new one. It has been familiar to observing vineyardists for fully twenty-five years, and it is probable that it has existed even longer. It is the severity of the attack which has this fall affected the vines that has made the Chautauqua vineyardists in particular anxious regarding the cause of the trouble and the remedies which may be applied to prevent its reappearance.

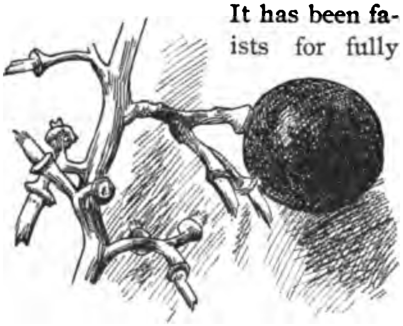

FIG. 1.—*Normal separation of berry from the stem.*

Description.—The shelling of grapes takes place in the following manner. As the season of ripening approaches, certain berries of the affected clusters fall to the ground on account of the inability of the main fibres and other connecting tissue of the fruit-stems to sustain their weight. Figure 1 represents a normal separation of the berry from the stem as commonly pulled off; Fig. 2 shows the manner in which this separation takes place in the case of shelling. The end of the stem is even, as if cut with a knife.

The portions of the cluster first affected are, so far as my observations go, invariably either the lower extremity of the cluster as it hangs from the cane, or, in the case of heavily shouldered clusters, the outer extremity of the stem forming the shoulder. The shelling may begin at both points at about the same time, but it generally makes its appearance first at the lower end of the bunch. Sometimes only one or two berries may fall, but in other cases the drying and shriveling of the stem gradually extends upward, the affected portion being plainly marked by the absence of the berries, as shown in Fig. 2. It often

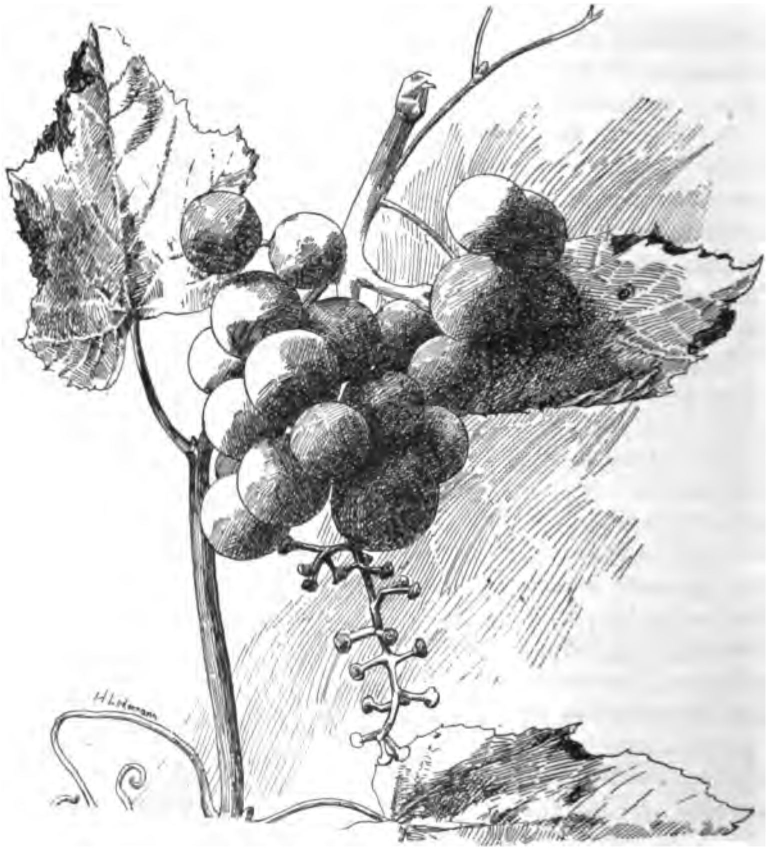

FIG. 2.—*Abnormal separation of berry from stem, as it occurs in shelling.*

occurs that not a berry remains hanging upon the bunch. In such cases the ground below the bearing portions of the vine is literally covered with the fallen fruit, and from a distance it presents, in the case of Concords, a strong blue color.

Some clusters upon a vine seem to be more free from shelling than others upon the same plant. This seems to be due in many cases to its location upon the cane, but there are so many exceptions that no definite rule can be laid down. In general, however, it may be said that of the clusters found upon a certain cane the one which is situated farthest from the main stem of the plant is most seriously affected. There are many exceptions to this statement, but the majority of cases which I have seen confirm it.

Another peculiarity which may sometimes be seen, although cases of it are very rare, is the shelling of berries upon only one portion of the vine, as for instance those borne upon the canes which spring from an arm, the difficulty thus affecting only one-half of the plant. One case was noticed in which the clusters found upon one cane were the only ones which suffered, amongst all those borne by the vine. The fact that such cases are seldom found would tend to show that they represent a singular phase of the disease, and are produced by some local cause, perhaps varying in the different cases. They cannot be considered as typical of the common form in which it appears.

It very commonly occurs that plants in certain portions of a vineyard shell, while the large majority of them do not. The line is sometimes so sharply drawn that the affected plant may be entirely surrounded by healthy vines; and it is not uncommon to find a healthy vine in the midst of those which shell. Occasionally the plants in a row are quite different as regards the amount of fruit which is lost, some retaining all, while others lose fully 75 per cent. Such vineyards, however, do not represent the large majority. In these, the shelling is more or less uniform throughout the vineyard, and only in exceptional cases does the loss reach 50 per cent. of the crop. The total loss in the "belt" will probably not exceed 5 per cent. of the entire yield this year.

The taste of shelled grapes differs decidedly from that of those remaining upon the upper portion of affected clusters and still more from that of berries which are borne upon vines in which no shelling takes place. This difference is very noticeable in Concords. Grapes of this variety, when grown under favorable conditions, are sweet and very agreeable to the taste, on account of a flavor which is peculiar to the variety. Shelled grapes are extremely insipid, and are unpalatable not only from a want of taste but also from a certain disagreeable flavor which, though seldom strong, is still perceptible. Berries which remain upon shelly vines lack flavor, but otherwise they do not appear to possess any particularly disagreeable qualities.*

Vines which have shelly grapes are almost invariably affected by what is commonly called the leaf-blight. This generally appears late in July or during August. This year it came on late in August and during the first week of September, which is about the time that the grapes began to fall from the vines. The blight causes the death of the leaf tissues, but all the leaves do not appear to be equally affected. The younger growths are the ones which suffer most. The leaves at the outer extremities of the shoots first show a yellow discoloration which follows more or less continuously the outer margin. Soon this yellow portion dies and turns brown. This causes the leaf to curl at the edges as shown in Fig. 3. As the disease progresses, older leaves are affected and in severe cases the amount of brown in the foliage is noticeable from a considerable distance. Many of the vineyards showed this discoloration so plainly that it was not necessary to enter them to be assured that the grapes were shelling.

The shelling of grapes is not invariably accompanied by any decided discoloration of foliage, nor is the browning of the leaf tissue a certain indication of shelling; but the few exceptional cases in which the one takes place without the other scarcely have sufficient weight to throw any serious doubt upon the probable relation existing between the two. I have been assured by several growers that in years past they have been able to tell during the summer which vineyards would shell during the fall, basing their conclusions entirely on the fact that the foliage began to assume this brown tinge. The leaves are not often entirely destroyed,

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* Chemical analyses of shelling grapes are now being made with the hope that some light may be thrown upon the subject by the berries themselves. In addition to this, fertilizer experiments have been planned and several are now under way to determine the kinds and amounts of fertilizers that are necessary to the proper maturing of a crop of grapes, and also to find what amount of fruit can regularly and profitably be borne by a vine without injury to it. The results of these investigations should be published as soon as definite statements can be made.

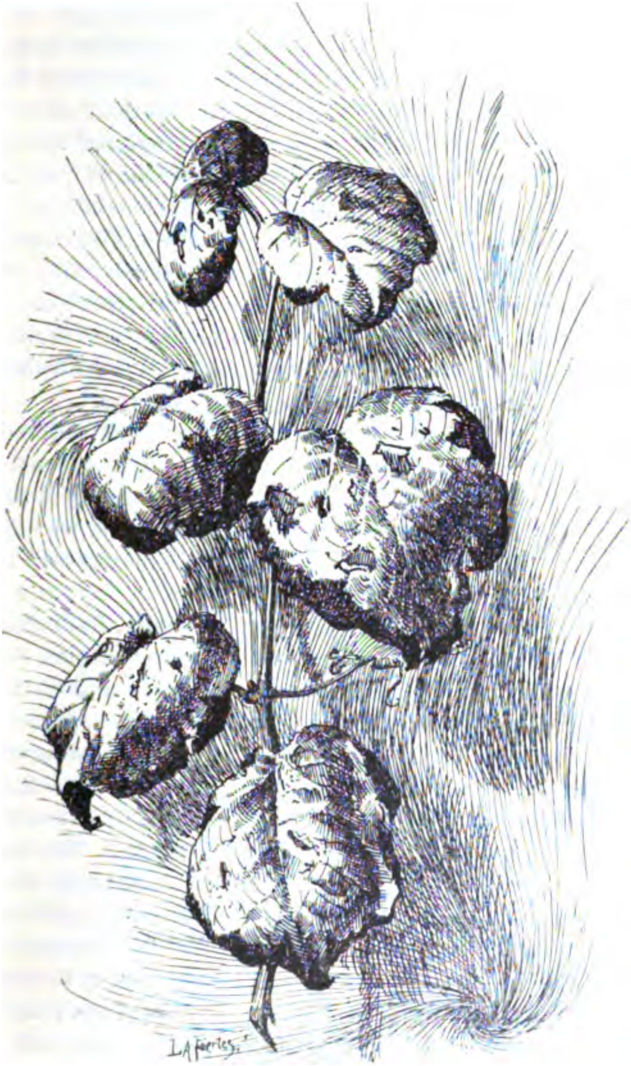

FIG. 3.—*Diseased foliage upon a shelling vine.*

for they remain upon the vines until fall, the green portions probably still acting in a normal manner.

A dark discoloration often found between the main veins of the leaves may be attributed to the same cause as that producing the death of the edges. These dark portions, (sometimes they are nearly black) do not necessarily indicate the death of such places for the thickness of the leaf is apparently normal and the marked curling of the leaf is wanting. In these respects the trouble seems to differ from the browning and drying of the leaf as mentioned above, and it may be due to some other cause. Inquiries during one season were insufficient for the drawing of more definite conclusions regarding the cause of this trouble. Below (p. 420) are also given descriptions of two diseases which attack vineyards in France and it is possible, although not probable, that this one is of a similar nature to the European ones.

In 1890 the grape growers of western New York suffered from a disease which caused the grapes to shell in some cases very severely. D. G. Fairchild, assistant in this section of Vegetable Pathology in the U. S. Department of Agriculture, was directed to investigate this trouble and an abstract of his report* is here given.

Definite reports of the trouble were received from Niagara, Wayne, Cayuga, Seneca, Steuben and Ontario counties, but it is probable that grapes were affected in other parts of the state.

"Small irregular bunches of a dark color appear between the veins, these enlarge rapidly, darken to a dull purplish or reddish brown and coalesce so as to fill up the space between the veins which remain green or yellow. These changes occur so rapidly that the foliage seems to change color suddenly. The contrast between the green or light yellow veins and dark purplish brown of the intervening tissues gives a peculiar streaked appearance to the leaves. In the most serious cases they curl up, become dry and brittle, and finally drop from the vine, leaving it nearly bare.

"The berries borne upon diseased vines, almost without exception, have a flat, insipid, and often intensely sour taste, due to the fact that they are only partially ripened. When the attack is severe the berries drop off, and the ground beneath a diseased vine is often seen to be covered with half ripe grapes. The berry is found to part from its pedicel taking with it the fibres which enter the interior of the pulp and are normally withdrawn from it when the berry is pulled off. After the crop has been harvested, also, the bunches are found to 'shell' badly, ruining them for market.

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*Journal of Mycology, vi. 96. Annals Hort. 1890. 74.

"The roots of diseased vines, when carefully examined, fail to show a healthy growth of young feeding rootlets. When the roots of healthy and unhealthy vines are compared, although as is to be expected late in the season (October 20–25) the fibrils have many of them dropped from all vines, the difference in favor of the healthy vines points quite plainly to the fact that root absorption was stopped earlier where the disease is present. The early stoppage of the action of the rootlets may account for the peculiar coloring of the leaves and failure of the canes to mature their wood. * * * A careful microscopic examination of all parts of the diseased vine has revealed absolutely nothing of the nature of a parasitic fungus which could in any way be connected with the malady. Leaves, canes and roots seem perfectly free from any form of parasitic plant or animal. * * * In general it may be said that the worst attacks of the disease occur upon cold, heavy soil containing a large percentage of clay and rich in nitrogenous matter. * * * So far as the investigation goes there seems to be no connection whatever between the fertilizer used and the trouble, diseased plants being found upon land unmanured, heavily manured, fertilized with phosphates, wood ashes, and bone dust."

The disease described by Fairchild is undoubtedly identical with the rattling or shelling of grapes as it occurred this fall, although the appearance upon the leaves has not been similar to that observed the past season. From somewhat incomplete meteorological data, I find that in general the season of 1890 resembled that of 1894. The spring was very wet, the summer inclined to be dry, and the months of September and October very wet.

In this connection it may be well to mention two diseases which attack French vineyards. They are frequently spoken of in connection with the shelling of grapes, and to assist in clearing up the problem the two diseases are described. The causes of apoplexy and rougeot are apparently clear, and meteorological conditions may be held responsible for their appearance. When we come to the origin of grape shelling, the same causes do not appear, and meteorological influences seem to assume but a secondary position.

*Apoplexie, or Folletage.**—These are the names applied to a phenomenon which generally appears in July or August in vineyards, especially in those growing on deep and rich soils, which previously showed no signs of disease. Upon isolated plants, or sometimes upon entire portions of a vineyard, there suddenly appear leaves which have lost their lustre, and their natural turgescence; in consequence they wilt and perish. The shoots dry from above downward, and soon the entire plant dies. The trouble however, is not always so severe as to cause the death of the plant. One portion only of the plant may be affected and the remainder be apparently healthy. But the shock to the plant is always severe, and generally the effects of such an attack are beyond perfect repair. The explanation which Leclerc gives† is as follows: "The rainfall during the year has been very heavy and thus prevented the rapid heating of the soil and also caused the atmosphere to be saturated with the vapor of water. In addition, the skies of Touraine have been almost constantly overcast. The growth of the vines was made, one might almost say, in the shade, and under these circumstances the tissues of the plant have not acquired the powers of resistance which they would have had if the sun had shone oftener. The tissues were gorged with water; the evaporation from the plant was slow in consequence of the humid condition of the air. The experiments of Sachs show that transpiration (evaporation) increases as the temperature of the soil is raised. Consequently the passage of water through the roots and the wood must have been slow and a certain balance was established between it and the process of transpiration. Let us suppose, now, that suddenly the burning rays of the sun strike the well developed foliage of the vines. The air is warmed, dried more and more as the temperature increases, and with the increased heat and dryness of the air the evaporation of the plant becomes more energetic. Since the water lost from the leaves and green parts cannot be instantly replaced by the roots, on account of the rate of circulation already established, those parts wilt, and when they have dried to a certain point they perish." In conclusion, apoplexy may be said to be due to a disturbance of the equilibrium existing between the absorption of water by the roots and its evaporation from the leaves. No remedy is as yet known for the trouble. Thorough drainage may lessen its severity in some soils.

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*G. Foëx, Cours Complet de Viticulture, 1891, p. 466 *et seq.*

†Ibid. p, 467.

Rougeot appears, from the conditions which cause it and by its general nature, to be allied to apoplexy. Like the latter, it attacks vines in full growth, at the time of the first heated periods, and is most serious upon cool, deep soils. Thiébaut de Berneaud says* that the disease is produced "during summer, after a cold rain, a storm which causes a sudden fall of temperature, or a fog which is followed by warm southerly winds." Marès describes the disease as follows: "The leaves begin to change, shrivel and lose their suppleness. The parenchyma turns red while the veins remain green, which gives the foliage a very peculiar appearance. The berries wilt and the shoots remain yellow. If the trouble increases, the leaves dry entirely and the stems die partially, sometimes only one side being affected, the diseased portion extending from the extremity to the base of the shoot. Such shoots often start a later growth during the latter part of the season. Plants attacked by rougeot do not die, as in the case of apoplexy, but they are severely checked, and several years are necessary to a complete recovery." Drainage should be carefully attended to, and particular pains taken to prune short, or at least down to sound wood. In extreme cases the plant may be renewed by grafting low upon the trunk of the vine.

Ascribed Causes of the Shelling of Grapes.—The causes which lead to the shelling of grapes are very obscure. Although the trouble has existed a long time among the vineyards of Chautauqua county, there are still numberless theories advanced as to the influences which produce it. Nearly every grower has a theory regarding it, but many confess that the disease is a mystery, and that none of the theories advanced will properly explain its appearance. The following are the more important of these possible causes:

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*Ibid. p. 469, cited from Nouveau Manuel complet du Vigneron Français, p. 186.

1. Insects.
2. Fungi.
3. Blight of the foliage.
4. Stems shrivel before the berries mature.
5. Berries prematurely ripe.
6. Premature ripening of the wood.
7. Overbearing.
8. Too much wood and foliage.
9. Too rich land.
10. The kind of soil.
11. Too much cultivation.
12. Excessive drought.
13. Excess of moisture after drought.
14. A weak root system.
15. Want of barnyard manure.
16. Want of phosphoric acid.
17. Want of potash or of some other element.
18. Excessive heat.
19. South wind.
20. West wind.

Such a variety of opinions regarding the causes that produce the shelling of grapes should include some at least which offer the true solution of the problem. Before considering the list in detail, it may be convenient to divide these opinions into groups, basing the division upon the close relationship existing between many of them. They fall readily into four groups, as follows:

I. Injuries caused by parasites: embracing Nos. 1–3.
II. Improper condition of the vine: embracing Nos. 4–9.
III. Condition of the soil: embracing Nos. 10–17.
IV. Condition of the atmosphere: embracing Nos. 18–20.

The various opinions will be considered individually so that their real value may be properly estimated.

GROUP I.

Injuries caused by parasites.

1. *Insects.*—It is believed by many that much, if not all, of the shelling of grapes is due to the action of insects. This point was constantly kept in mind during the examination of vineyards, and both clusters and vines were searched for insects which might be supposed to cause the trouble. In not a single case, however, did I discover any pest to which could be attributed the shelling of the grapes, and this theory had to be abandoned from want of evidence. If the trouble is caused by an insect, it works "in ways that are dark and devious" and when found will prove to be very interesting.

2. *Fungi.*—A majority of the vineyards visited were found to be infested with powdery mildew (*Uncinula spiralis*). This was found growing abundantly upon the leaves and fruit-stems of some vines and traces of it could be found in almost every vineyard. This mildew appeared late and was not found upon any berries. It formed a white mealy coating upon the main stems of the clusters, but comparatively little was found upon the pedicels of the individual berries. Its presence upon the foliage could easily be detected by the silvery-gray appearance of certain portions of the upper side of the leaf, these areas being very plainly marked in those portions freely attacked. Almost the whole of this fungus rests upon the leaf, and only the suckers which are in search of nourishment enter into the leaf tissue. This permits the parasite to be rubbed off very easily and the only trace of its former existence upon the leaf is a darkening or blackening of the portion which was most thickly covered.

In severe cases this fungus will cause grapes to fall from the vines, for the following reason. Let us suppose that the stem of a cluster is thickly infested with the mildew. A great many suckers will be sent into the green portion of the stem and much nourishment will be taken away from the berries. Another effect will be to obstuct the free flow of sap and this will again cause the berries beyond the point of injury to be deprived of the materials which were originally intended for their use. "We sometimes find nearly full-grown berries completely overgrown with mycelium of the *Uncinula* so that the brown specks above mentioned, [produced in the berries by the action of the suckers] if present at all, are completely hid from view. These berries eventually become dry and shrivelled, and finally drop off.''*

If the shelling of grapes as it occurred this fall were entirely due to the presence of the powdery mildew, then the degree of shelling should be directly in proportion to the severity of the attack of the mildew. The vineyards, however, did not bear out this proposition. Vines in which scarcely a trace of mildew could be found, frequently lost a large amount of their fruit, and again many clusters were seen having their stems literally covered with the fungus, yet no berries fell to the ground. The frequency of such cases has led me to believe that the powdery mildew is not the principal cause of the shelling of grapes, although in certain cases it may have exerted an influence in this direction, and possibly some berries fell from this cause alone. The cause for the bulk of the shelling must be sought elsewhere.

3. *Blight of the foliage.*—By the term "blight" is meant the browning of the leaves as already fully described upon page 416. Affected portions have been examined under the microscope but no traces of insect or of fungous injury could be found. The manner in which the leaf succumbs indicates that the trouble is not local, but that something is wrong in the whole plant economy. Consequently it seems to be safe to say that the so-called blight is not a cause of the shelling of grapes, but it rather appears to be a condition resulting from the same causes which make the berries drop to the ground; in other words, the browning and dying of the edges of the leaves and of those portions situated farthest from the main vines is to the leaf what the dropping of the lower berries from a cluster is to that cluster. Neither is dependent upon the other, and both are the result of some common cause.

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*Scribner's Report on the Fungous Diseases of the Grape Vine. U. S Dept. of Agric. Bot. Div. Sec. of Veg. Path. Bull. II. p. 22.

GROUP II.

Improper conditions of the vine.

4. *Stems shrivel before the berries mature.*—From the peculiar manner in which the lower end of the stems of fruit clusters shrivel and dry, one would naturally be led to suppose that the green wood failed to ripen. This shrivelling of the stem necessarily cuts off the supply of nourishment from the fruit, which in consequence drops. But the true question now is, what is the cause of this shrivelling? When that is answered, we shall have the answer to the question regarding the cause of the shelling.

5. *Berries prematurely ripe.*—This is little more than a mere statement of the fact that when grapes are perfectly ripe they separate from the cluster in the same manner as do the shelled grapes. That this ripening is premature is evident, for the large majority of berries still remain upon the vines while the others are falling. This theory throws no light upon the cause of the trouble.

6. *Premature ripening of the wood.*—In case the wood of a grape vine ripened prematurely, it would undoubtedly exert an influence upon the fruit itself. The character of this influence would probably vary with the age of the berries. If a cane bearing clusters be broken during midsummer when the fruit is about one-half grown, the berries will not fall to the ground, but they will remain hanging upon the stems even after being perfectly dry and shrunken. Although such wood is not properly ripened, it resembles well ripened wood by not admitting of the free passage of nourishing elements. The same result is obtained when a certain portion of a cluster is girdled by anthracnose. If such accidents occur when the berries are fully grown or coloring, the effect may be different, for then there may be sufficient nourishment present to enable the berry to continue to ripen, although imperfectly, and to allow the natural separation of berry and stem to take place. But even if it is granted that the shelling of grapes is due to the premature ripening of wood we are still in search of the cause of this ripening.

7. *Overbearing.*—A vine overbears when it sets more fruit than it can ripen without interfering with the production of a sufficient

amount of healthy foliage and wood. Vines which have set too much fruit show it in the comparatively little amount of new growth, in the smaller size of the leaves and fruit, and in the slowness with which they ripen their fruit. There are, of course, many degrees of overbearing and appearances will not be identical in the different cases. In severe cases the berries grow slowly and color slowly, and they may remain unripe until very late in the season, or perhaps never ripen well. It has already been stated on page 425 that grapes must attain a certain degree of maturity before they part naturally from the stem. It is probable that in some severe cases of overbearing the berries never reach this point. I have seen, on Cayuga Lake, Catawbas which, during the season just passed, had only begun to color on October 5. Yet they did not shell. Other vines in the same vineyard, some having much better colored fruit, did lose a few berries. These vines appeared to be carrying too much fruit, still it was fairly well colored ; similar cases were also seen in Keuka Lake vineyards.

The effects of overbearing are not limited to one season, but the plant may suffer for a year or two on account of the weak condition in which it was left at the close of the first, and it is not improbable that this weakened condition may be exhibited by the grapes shelling. Still, in visits paid to the vineyards of Chautauqua county the yield per acre seemed to have little connection with the degrees of shelling, and strong vigorous foliage was by no means a proof that the grapes were not shelling ; in many cases it was quite the contrary as regards the character of the foliage. In fact, some growers have advanced the idea that the vigorous foliage was the cause of the trouble.

8. *Too much wood and foliage*;

9. *Too rich land.*—These two theories can properly be considered together as the last named is the cause of the other. Their origin probably lies in the fact that vines growing in strong black land, that which is commonly found in hollows and which is frequently called black walnut land, are particularly apt to shell, while vines growing on higher land hold their fruit. I have seen in the vineyards of Mr. E. H. Fay, Brocton, N. Y., rows which began to shell as soon as they dipped into this dark, loamy soil, yet just above no grapes fell. The land is undoubtedly rich, but is it rich

in the proper elements? Nitrogen is there in more than sufficient quantities, but other things than nitrogen are wanted for the perfecting of a grape crop, and it is very possible that some of those other elements may not be present in proper quantities to supply the demands of the larger amount of wood which has been made, as well as to ripen the fruit properly. In case there is not enough food the fruit will be the first to show the effects.

On higher land where the growth is not so rank, the demands of the ripening wood are not so great and the fruit is better cared for. Too much nitrogen, therefore, is detrimental to the profitable development of the grapes.

GROUP III.

Conditions of the soil.

10. *The kind of soil.*—That the shelling of grapes is worse as a rule upon some soils than upon others is a very common belief, and the subject is closely related to the two preceding. About Ripley, the soils which are supposed to produce shelling vines are the low rich lands, the higher ones being free. I found an exception to this rule in the vineyard of Mr. H. J. Lewis, and about Portland several cases could be mentioned in which the high land shelled as badly as the low. At Forestville it is a common saying that clay lands are free from the trouble, but there are many cases which contradict the statement. My observations have led me to the conclusion that the character of the land is not an indication of the degree to which the grapes will shell. This reservation should nevertheless be made: that lands which are rich in nitrogen, and which consequently make an unusually strong growth of wood and foliage, are strongly inclined to produce vines which shell, while lands making a normal amount of wood and healthy foliage are inclined to be free from the trouble.

11. *Too much cultivation.*—The effect of too much, or too late cultivation, is practically the same as that of feeding plants nitrogen. It cannot be denied that the amount of shelling found in poorly cultivated vineyards has on the whole been less than in those which have been well cultivated, other things being equal.

It is said that one grower boasts of harvesting from his vineyard two tons of hay and three tons of grapes per acre; yet his grapes did not shell. I have seen a case* in which two men owned adjoining vineyards which were growing on the same land and had had the same treatment in past years. During the past season one had not been cultivated and the other had been. The latter shelled considerably, the former practically none. Vineyards that were growing nearly in sod were almost invariably free from the trouble. Many vineyards that were not cultivated also shelled, but unquestionably the well cultivated vineyards suffered more than those which were not so thoroughly tilled. The explanation for this fact is probably the same as that which will clear up the shelling of grapes upon the soils rich in nitrogen, since tillage promotes nitrification, which in turn causes a strong growth of wood.

12. *Excessive drought.*—Many attribute the shelling of grapes to the very dry weather. The grape season of 1894 was about ten days earlier than usual; Catawbas colored and ripened to perfection, and the quality of all varieties was exceptionally good. These undoubtedly are results of the drought, and why should not shelling be equally so since it has been so unusually severe? Several objections can be raised to this theory. If the shelling was due to the drought entirely, vineyards upon the same soils should have suffered with the same uniformity with which their grapes colored and ripened, or received their excellent flavor. Again, if drought is the only cause of shelling, vineyards growing upon moist soil should have been free from the trouble. One vineyard belonging to Mr. E. H. Fay, of Brocton, N. Y., was planted upon soil which remained moist throughout the summer; in fact, open ditches held running water during the worst of the dry weather. Nevertheless, this vineyard shelled, but not from want of water. It is situated upon the black rich land already mentioned and shelled probably for the same reason that others in similar situations did.

There seems to be, nevertheless, some connection between the prolonged dry weather and the shelling. It appears to me that this connection can best be explained by the supposition that the dry condition of the soil prevented the plant food from going into solution, for unless it is in solution it cannot be taken up by the plant. This shortage of plant food, or defect of nourishment, would have a tendency to cause the plant to ripen its crop earlier than usual, which indeed did take place. But the grapes which fell to the ground were not fully ripened, nor were the majority of those which remained hanging upon these vines. The taste showed that there was something wrong in their development, that the sweetness and aroma proper to the variety were wanting. This was undoubtedly due to some defect in the nourishment of the berries, and this defect may have been and probably was intensified by the dry weather.

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* **Messrs. Randall and Lewis, Ripley, N. Y.**

13. *Excess of moisture after drought.*—To what extent the rains which followed the drought influenced the shelling it is difficult to say. It is probable that the principal injury had already been done when these rains came, and the sudden supply of plant food may merely have hastened the last stages of the ripening of the berries and thus have caused them to fall a little sooner than they otherwise would have done. But to what extent this took place cannot be said.

14. *A weak root system.*—It is a generally conceded fact that young vineyards suffered more than old ones. Probably the severest cases could be found among vineyards which were bearing their second or third crop. Although many of the older vines suffered, the average loss from these was probably not so great as that from the younger plants. Since the younger plants were not so well established, they would not have the same opportunities of obtaining food as the older ones. The area covered by the roots would be smaller, they would not extend to an equal depth, nor would there be so many of them. This would result in an insufficient nourishment of the plant, a premature and probably an imperfect ripening of the fruit, and finally the falling of the berries. I think it very probable that in the case of the young vineyard belonging to Mr. E. H. Fay, already mentioned on page 428, that although the land was sufficiently rich in nitrogen it was lacking in some other equally important element; or, since the land itself is so very low and wet, it is very possible that it is not well adapted

to a healthy growth of the Concord grape. Either of these causes might tend to produce shelling.

That insufficient nourishment does cause grapes to shell is clearly shown in Figure 4. This Catawba cane was found in the vineyard of Messrs. King & Robinson near Trumansburg, N. Y. The first thing which attracted my attention was the light red color of the berries upon the central cluster. They were just turning, while the clusters on either side were colored a dark red. Upon closer examination the cause of the trouble became apparent. It will be seen in this illustration that the two outer clusters hang directly down from the underside of the cane. The stem of the central cluster, however, is attached on the upper side of the cane and the weight of the fruit has caused the stem to bend at a very acute angle, thus seriously interfering with the flow of sap.

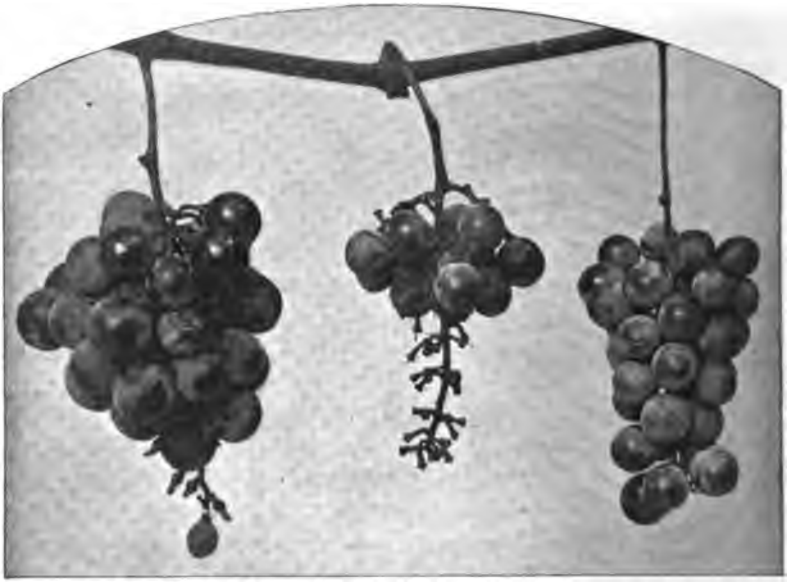

FIG. 4.—*Obstructed flow oj sap the cause of shelling.*

Another interesting point was soon noticed. The lower berries of the cluster separated in the same manner as that which takes place in the case of shelling; most of the berries parted regularly from the stem as if cut with a knife. The berries on the neighboring cluster parted in a different manner, for the connecting fibres remained attached to the peducle, as shown in the figure. Here was positive proof that improper nourishment caused a marked weakening in the connection between berry and stem, and undoubtedly it was merely a matter of a short time before the berries would have shelled as completely as some others in the same vineyard were doing. With the others, however, it seemed to be a clear case of overbearing, which to the fruit is nothing more than a want of proper food.

15. *Want of barnyard manure.*—This cause for the trouble is here mentioned because Mr. H. B. Clothier, of Forestville, N. Y., assures me he has stopped the shelling by the use of barnyard manure which was taken from the stables of horses fed with grain. The use of stable manure, however, has not always been followed by such satisfactory results, and it may and sometimes does do injury by promoting an excessive growth of wood.

16. *Want of phosphoric acid.*—The lack of this substance in available form in the soil has been advanced as a possible cause of the grapes shelling. The use of phosphorus to the plant is very imperfectly understood. It is supposed to assist in the diffusion of soluble albuminoids, or those compounds which contain nitrogen. Nothing definite can be said of the relations existing between the shelling of grapes and the action of the phosphates.

17. *Want of potash.*—Probably more vineyardists agree upon attributing the shelling of grapes to a want of potash than they do upon any other cause advanced. There are several facts which favor the theory.

Potash is an essential element of plant food. Experiments carried on by Nobbe, Schrœder, and Erdmann* seem to prove conclusively that the office of potash in the plant economy is to assist in the formation of starch. Plants of Japanese buckwheat were grown in a solution free from all traces of potash. After a few weeks all growth had stopped. Examination of the plant failed to show any starch except traces in the green portion. When potash salts were added the plants began to grow again and starch was formed.

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* Versuchs-Stationen, xiii. 1870, p. 357; cited by Goodale, Physiological Botany, p. 252.

The development of sugar in fruits is dependent upon the presence of starch, for in the plant this substance is changed into the sugars, which sweeten the fruits. Some experiments have been made which have particular bearing upon this point. Dr. Stone, of the Massachusetts Agricultural College* makes the following statements: "A wild specimen of Vitis Labrusca (our common wild grape) was torn apart at its root; one half was left in its natural condition, the other transplanted to cultivated ground and treated with nitrate of potash and bone superphosphate. At the end of three years fruit from the cultivated vine contained twelve per cent. more potash and twenty per cent. more sugar than that from the wild one." Dr. Stone declared also that "potash fertilizers have decidedly improved the desirable qualities of our fruits. Wherever the percentage of this element has been raised the change is accompanied by an increase of sugar and decrease of acid." Other examples might be given, but these will answer for the present purpose.

All grape growers are agreed that the flavor of shelled grapes is none of the best; in fact such grapes are very insipid. Although this does not necessarily prove a lack of potash, the probabilities are that such is the case. All other causes which might produce such a result have been almost entirely excluded, so that we are apparently forced to accept this as the true cause of the difficulty. By a lack of potash is not meant necessarily that the soil is deficient in this element, but rather that it is not found in a form which makes it available as plant food.

The reasons for this want of potash are not very difficult to find. The lands upon which the majority of the Chautauqua vineyards are now growing had been used for many years for the production of grain and hay. Almost no fertilizers had been returned to the soil and the natural consequences followed. The supply of available plant food in the soil has become more or less exhausted.

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*Amer. Gard. vi. 210 (1885), cited by Bailey, Agricultural Science, vi. No. II. 1892, p. 500.

In favorable seasons this may not be very apparent, but in seasons such as the past one, when the soil becomes dry and the quantity of available food in consequence more restricted, the effects of former croppings become visible upon lands which were not exceptionally rich in the first place. In the vineyard of Mr. S. Codington, of Fredonia, N. Y., this view of the case was very strongly emphasized. The vineyard is in the form of a square, and I was told that there was a strip stretching diagonally across the field from corner to corner, in which the vines shelled badly. Upon closer examination the line of shelling seemed to extend squarely across the vineyard in such a manner that about one-half shelled very badly, the other half but little. The portion which shelled the most was formerly used as a meadow and had been so used for fully twenty years. The other part had been set in the place of an old orchard which had been used as a cow pasture for more than twenty-five years. The line separating the orchard from the meadow could be traced plainly in the vineyard by the degree of shelling. There can be no doubt that much of the shelling is due to impoverished land.

It is not common to find a vineyard which was set upon old pasture or upon new land, that shells to any considerable extent; most of these vines hold their fruit well and the contrary is the exception rather than the rule.

Fortunately we have proof that in some cases, at least, potash has stopped the shelling. But two examples can be here mentioned, but they are convincing.

Geo. W. Marsh, of Portland, N. Y., had been troubled with the shelling of his grapes for some years, on a rather low portion of his vineyard. Potash in the form of kainit was applied in the spring of 1894, at the rate of one pound per plant. This application seemed to be heavy enough, for the leaves did not show the "blight" during the following summer and the grapes did not shell in the fall. M. L. Taylor applied one ton of Canada hardwood ashes upon his vineyard; it adjoins that of Mr. Marsh and is upon the same kind of land, but the applications were of practically no value. If the analyses of Canada hardwood ashes were always uniform, or if they invariably showed an abundant supply of potash, this result could hardly be explained. But in view of the success which has followed the use of potash salts, I am inclined to believe that the ashes were not up to standard quality.

The second case is that of Mr. F. W. Howard, of Fredonia, N. Y. The experiment which was tried by Mr. Howard is one worthy of being followed by every grape grower in the Chautauqua district. He divided his Concord vineyard, which is practically level and is upon a soil very uniform in character, into several plots and applied fertilizers at the rate of two hundred pounds per acre, as follows:

16 rows, applied a mixture of equal parts muriate of potash and bone.

6 rows, muriate of potash.

6 rows, bone.

6 rows, tankage.

64 rows, equal parts tankage, bone, and potash.

7 rows, potash and bone.

4 rows, nothing.

These applications were made in the spring of 1894, upon land that had shelled in previous years. The results were so plainly marked that there was no room left for doubt as to the requirement of the land in this vineyard. The first plot of sixteen rows shelled, but not seriously. The next six rows, to which the muriate of potash had been applied, scarcely lost a berry, nor were leaves "blighted" to any greater extent than might be expected so late in the season. In passing to the next plot, the one to which the bone was applied, it was unnecessary to ask where the dividing line between the two plots was situated. The difference could be seen to the row. Where the bone had been applied, the berries shelled to such an extent that the ground was fairly blue in some places. It seemed as if fully one-third of the crop had fallen. The remainder of the plots showed improvements directly in proportion to the amount of potash used, the other materials applied being apparently without effect. The land upon which this vineyard stands was formerly used for farming purposes and was cropped continuously for fifty years or more with scarcely any fertilizers having been applied. The wonder is not that grapes shell, but that they do not all loosen their hold upon life and return to the soil from which they sprang.

GROUP IV.

Conditions of the atmosphere.

18. *Excessive heat.* If a very high temperature were the sole cause of grapes shelling, one should expect to find the shelling equally severe in vineyards having a similar exposure; and those vineyards in which the greatest heat occurred should show the worst shelling. But this is not the case. Some vineyards, and one belonging to Mr. E. H. Fay, of Brocton in particular, are so surrounded by trees that the south wind is the only one which can enter the vineyard freely. Mr. Fay told me that the heat in this vineyard was so intense that it is impossible for the men to work in it, and they are consequently given work elsewhere during the hottest days. The land has a southern exposure, it is protected on the north, west and partially on the east by trees, and it thus forms a pocket in which the heat accumulates sometimes to an intense degree. Yet this vineyard did not shell during the past season, with the exception of a small strip along the lower edge in which the soil was heavier and more moist.

19. *A south wind;*

20. *A west wind.*—These two causes have been advanced as being possibly responsible for the shelling. It has also been said that a north wind stops the trouble. At first thought it would seem that there can be no connection between shelling and the direction from which the wind blows. But, nevertheless, it is not impossible that such a relation may exist. A wind from the south or from the west is generally warm, and this warmth favors active growth and the development of the fruit. This activity of the plant may well be carried on at the expense of the fruit, especially if the supply of nourishment be limited. A north wind, being cool, would of course have an opposite effect, and check the plant's development.

Remedies.—After the above detailed discussion of the possible causes of the shelling of grapes it would appear that the one cause which appears to lie at the bottom of the trouble is *defective nourishment.* All influences which aggravate this condition may be held as being indirectly connected with the trouble, and they may even be the exciting cause of it. The drought, for instance, may have had such an action on the supply of plant food that it prevented the plant from getting it, while if the season had been more favorable the vine might have pulled through and the owner would have been none the wiser.

The first step to take in order to remedy the shelling is unquestionably to study the needs of the soil in which the vineyard is growing. Mr. Howard is fully satisfied as to the needs of his vineyard, and it is very possible that his vineyard has suffered from shelling for the last time. I should hesitate to say that it is from a lack of potash that all the Chautauqua vineyards have shelled, yet it is probable that in a very large majority of cases this is the cause of the trouble.

Cultivation seems to have aggravated the trouble in soils which were not well supplied with all plant foods. It appeared to favor a growth which the plant was unable to ripen properly except at the expense of the fruit, for potash is as necessary to ripen wood properly as it is to add flavor to the berries. The much discussed subject of the amount of cultivation proper to a vineyard is here touched upon but cannot be discussed. The same rule will probably not apply to all vineyards ; yet all cultivation which produces an excessive growth of wood and foliage should be avoided.

The weakening of vines by allowing them to overbear is another factor which seems to be responsible for some of the trouble. The young vines are the ones generally most seriously affected, probably because the roots do not penetrate into so much soil nor into such deep soil that a large food supply can be furnished the growing parts of the vines even under favorable circumstances. When young vines are allowed to bear heavy crops the food supply of those vines should be very carefully considered.

The powdery mildew was quite severe in many of the vineyards during the past season and a part of the shelling was without doubt caused by it. This mildew is one of the easiest to keep in check when it appears early in the season, but later attacks are more difficult to control as then there is danger of staining the fruit if late treatments are made. On page 441 will be found more definite directions regarding the treatment of this fungus.

Opinions of growers.—Having considered the possible and probable causes of the shelling of grapes in a general way, it will be interesting to note how far actual cases will bear out the conclusions which have been reached. A circular asking for information was published and submitted to the growers of Chautauqua county. The following cases are replies which have been received and also answers obtained in personal interviews. They are here stated in an abbreviated form but, on the whole, contain the most important portions of the answers. The most severe cases of shelling are placed at the end of the list.

Ralph Hall, Brocton. *Soil*, strong shale and loam; *Fertilizer*, applied four hundred pounds low grade potash to a vineyard that shelled in past years; *Shelling*, none in 1894.

Jonas Martin, Brocton. *Soil*, strong gravel loam; *Fertilizers*, experience has proved that shelling is not so serious when potash fertilizers are used.

G. H. Barber, Westfield. *Soil*, some gravel and some loam. This is inclined to be dry, and originally was strong land; *Fertilizers*, in the fall of 1892 applied two hundred pounds bone flour, and in the following spring two hundred pounds muriate of potash. Also some barnyard manure. The vineyards cover twelve acres. *Shelling*, none except from two rows situated fifteen feet from a row of apple trees, these being about six inches in diameter. *Probable cause*, the roots of the apple trees robbing the grapes of nourishment.

S. Dean & Bros., Brocton. *Soil*, generally a rather heavy gravel loam, formerly used for farming purposes; *Fertilizers*, have been using stable manure and potash fertilizers during the past ten years. Make applications of about three tons of good ashes per acre. Ten years ago one piece shelled badly; nearly a wheelbarrow load of manure was put about each of several vines and the next year these did not shell, while those around them did. *Shelling*, at present practically none.

Geo. W. Marsh, Portland. *Soil*, heavy gravel loam, inclined to be wet in a low place; *Fertilizers*, used kainit, one pound per plant; *Shelling*, practically stopped where it was formerly serious and no blight on the leaves.

E. Buckner, Brockton. *Soil*, mostly gravel loam; *Fertilizers*, not manured lately, but formerly well fertilized with stable manure. Hay and grain were raised on the land for about twenty years previous to setting the vineyard. *Shelling*, very little on the gravel, more on low, heavier land.

A. W. Lewis, Brocton. *Soil*, high gravel; *Fertilizers*, none for many years. The vineyard weedy and apparently somewhat neglected. The land was formerly used for growing hay and grain, the vineyard now being from twenty to twenty-five years old. *Shelling*, none.

L. Roesch, Fredonia. *Soil*, dry gravelly loam, naturally poor; *Fertilizers*, two tons Canada wood ashes per acre, also some stable manure; *Shelling*, none.

Henry Case, Brocton. *Soil*, gravel loam; *Fertilizers*, applied two tons of Canada ashes in spring of 1894 upon seven acres; *Shelling*, one part of the vineyard is eight years old and this shells; the other part is thirty years old, but does not shell.

Hermon L. Kent & Co., Westfield. *Soil*, mostly dry clay, originally poor; *Fertilizers*, yearly application of stable manure; *Shelling*, none. Insects the probable cause of shelling, and not lack of vitality in the vines. Some of the very richest and best land has shelled grapes.

A. H. Harris, Westfield. *Soil*, rich, dry gravel; *Fertilizers*, one pound sylvinite to the vine; *Shelling*, none where potash was used, some where it was not used.

A. N. Taylor, Westfield. *Soil*, a dry gravel, naturally rich; *Fertilizers*, potash at the rate of four hundred pounds per acre; *Shelling*, less than one per cent.

Professor W. A. Holcomb, Ripley. *Fertilizers*, applied one ton of sulphate of potash on ten acres in 1893, and this year a light dressing of wood ashes; *Shelling*, none.

O. J. Tefft, Ripley. *Soil*, gravel with low places; *Fertilizers*, used one quart of good maple ashes per vine; *Shelling*, most of the vines shell, particularly in the low muck ground.

G. Schoenfeld, Westfield. Formerly had charge of a vineyard. *Soil*, gravelly loam; *Fertilizers*, one, to one and one-half pounds of muriate of potash applied in the spring to the vines which shelled the fall before, stopped the trouble.

E. W. Skinner, Portland. *Soil*, gravelly loam; *Fertilizers*, applied half a pound of German potash salts to plants when they were set several years ago. About the same amount used again in 1893. *Shelling*, nearly twenty per cent.

J. A. H. Skinner, Brocton. *Soil*, 1, a heavy sandy loam, rather low, and formerly used for pasture; 2, a gravel loam, high ground, formerly used as a garden; 3, a lighter soil used for raising grain; 4, shale loam, upon which stood an orchard; *Fertilizer*, none; *Shelling*, piece 1, none; 2, about 5 per cent.; 3, from 15 per cent. to 25 per cent.; 4, none along the borders of the vineyard, from 1 per cent. to 10 per cent. in the interior.

Chas. Payne, Brocton; *Fertilizers*, much stable manure used continually; *Shelling*, the vineyard was set three years ago. This year it set heavily and shelled severely.

A. Kelly, Brockton. *Soil;* varies, sand, loam, clay; *Fertilizers*, applied two hundred pounds raw bone meal per acre where the plants were set six years ago. Since then four hundred pounds of potash have been applied twice. *Shelling*, about 5 per cent., there being apparently no difference in severity on the different soils.

George S. Kent, Westfield. *Soil*, a loam inclined to be heavy and poor; *Fertilizers*, mostly horse manure for several years. Last year used on a part sulphate of potash costing $50 per ton, and some years before ashes to a considerable extent. *Shelling*, none except on three or four Concord vin growing in an alluvial deposit of several inches of dark soil. It is the richest part of the vineyard and I never added manure thinking it needed none.

E. H. Fay & Son, Portland. *Soil*, side hill of loam and coarse gravel inclined to be dry. It is rather shallow and poor and was used not less than fifteen years as a cattle and horse pasture; *Fertilizers*, none. *Shelling*, only occasionally a bunch.

T. J. Walker, Ripley. *Soil*, both gravel and clay soils, well drained and fairly rich; *Fertilizers*, applied potash in 1893 at the rate of one pound to the vine, and also stable manure. *Shelling*, about 1 per cent.

A. W. Rumsey, Westfield. *Soil*, rolling, the hollows being of soil worked down into them, and all quite well drained; *Fertilizers*, a very little stable manure. *Shelling*, about 1 per cent., occurring mostly in the lower parts of the vineyard. *Probable cause*, a superabundance of foliage absorbing all the moisture during drought at the expense of the fruit.

Fraser & Co., Westfield. *Soil*, gravelly loam and sandy loam. Was cropped in parts for many years with grain and hay; *Fertilizers*, wood ashes and bone in some sections, muriate of potash and mixed fertilizers in others, and occasionally a little compost of stable manure. *Shelling*, lost by shelling probably 2 per cent. to 3 per cent.

A. B. Hawkins, Ripley. *Soil*, dry gravelly loam, naturally rich; grain and grass grown for many years; *Fertilizers*, animal manures. *Shelling* from 2 per cent. to 5 per cent., but where the manure was applied the grapes did not shell.

Jno. W. Spencer, Westfield. *Soil*, shaley clay with bed rock within thirty inches of the surface; *Fertilizers*, two years before being on the vine applied a shovel of stable manure to each plant each season. First crop nothing; second crop, four hundred pounds muriate of potash and four hundred pounds bone on one and three-fourths acres; third crop (1894) one hundred pounds unleached hardwood ashes on the same land. *Shelling;* shelling goes by plants, some plants 50 per cent., average 5 per cent. on piece of one and three-fourths acres. [While in conversation with Mr. Spencer he said that the worst shelling was in those portions of the vineyard in which the underlying rock came nearest the surface. E. G. L.] *Probable cause;* fungous disease on part or whole of them; plants not having proper formula of food are most susceptible to disease.

Chas. E. Brown, Ripley. *Soil*, rich black loam, rather wet; *Fertilizers*, heavy dressings of barnyard manure. Shelling, 5 per cent. *Probable cause;* might be mildew, is usually worst where vines have the most foliage.

B. M. Taylor, Portland. *Soil*, mostly rich, dry gravel with occasional hard loam in low places; *Fertilizer*, one portion barnyard manure, another salt and ashes. *Shelling*, none. *Probable cause*, drought and want of fertilizer. One of the worst vineyards I had last year received a good dose of salt and ashes and this year it has the best fruit of any and does not shell.

R. G. Wright, Westfield. *Soil*, rich black loam, clay subsoil. *Fertilizers*, not any until last spring when I applied potash at the rate of five hundred pounds per acre upon one-half, and fourteen two-horse loads of rich horse manure upon the other half. *Shelling*, none, except six rows which I did not fertilize. These shelled badly.

M. L. Taylor, Portland. *Soil* similar to that of Mr. Geo. W. Marsh and adjoining it. *Fertilizers*, applied one ton Canada ashes in 1893 and in 1894 repeated the application. *Shelling*, apparently not benefited by the ashes and about 40 per cent. of the grapes dropping in the worst portions.

S. S. Grandin, Westfield. *Soil*, a dry shale, originally not very good; used about 10 years in raising grain. *Fertilizers*, on the shale none. *Shelling*, 30 per cent. to 40 per cent. On other land that was manured the shelling was from 13 per cent. to 20 per cent.

E. H. Fay & Son, Portland. *Soil*, low, flat land consisting of rich, black muck. It was used for growing hay for twenty-five years before the vineyard was set. *Fertilizers*, none. *Shelling*, about 20 per cent. *Probable cause*, extremes of wet and dry weather.

E. D. Warner, Forestville. *Soil*, part gravel and part muck mixed with loam, this last being inclined to be wet. *Fertilizers*, the land has had barnyard manure more or less for twenty-five years, during which time it was used for meadow. Last fall, and the fall before, applied one shovel barnyard manure about each plant. *Shelling*, from 12 per cent. to 25 per cent. of the crop. *Probable cause;* about here the vines do not shell so much on clay land as upon other soils; they seem to be worse also upon richer lands. There is a meadow on the west side of my vineyard and the two rows next the meadow do not shell; the third row but little, and the trouble increases towards the center of the vineyard. Nor is there any shelling at the ends of the rows.

Franklin Peck, Westfield. *Soil*, not very good and naturally rather poor. *Fertilizers*, none worth mentioning. *Shelling*, 20 per cent.

Frank Maginnis, Portland. *Soil*, clay loam, poor, thin, and dry. During four years previous to setting the vineyard the land was sown to oats, two hundred and fifty pounds of phosphates being used to the acre. The average yield of oats was thirty bushels per acre. *Fertilizers*, in setting vines used high grade phosphates; in 1893 used twenty-five hundred pounds of high grade potash on ten acres. That is the part that has shelled the worst. Have used no other fertilizers in six years. *Shelling*. nearly 25 per cent.

R. A. Hall, Brocton. *Soil*, black rich loam, rather wet. *Fertilizers*, none. *Shelling*, 50 per cent.

C. M. Whitmier, Brocton. *Soil*, gravelly loam, well drained. *Fertilizers*, applied liberal quantities of a mixture of tankage, bone meal, dried blood, and sheep manure to the first row or each side of a road passing through the vineyard. *Shelling*, very little on the treated rows, 20 per cent. to 30 per cent. on the rows back of the first ones.

B. POWDERY MILDEW.

(*Uncinula spiralis.*)

The appearance of this mildew has been described on page 423. The fungus begins to attack the grape early in June and then continues to spread with greater or less severity throughout the growing season. Dry weather seems to assist in holding it in check, and warm rains are sometimes followed by very severe attacks.

The early applications which were formerly recommended in the treatment of most of the diseases of the grape are not now so strongly insisted upon. For the treatment of the powdery mildew, the following applications should be sufficient. The Bordeaux mixture or the ammoniacal carbonate of copper may be used (see page 450, 451). It is perhaps better to use the Bordeaux early in the season, and later the ammoniacal solution.

First application, about a week before the blossoms open.

Second application, about a week after the blossoms fall.

Third application, about two weeks after the second treatment.

Fourth application ; in many cases this can be omitted entirely. The time for making it cannot be definitely stated, but it may be required some time within two to four weeks after the third.

Mr. J. A. H. Skinner, of Brocton, has been very successful in controlling this mildew by the use of the ammoniacal solution alone. As this is much more easily applied, it may be safe to use it exclusively. In making the applications care should be taken to *strike the clusters* as well as the foliage, for where there is none of the fungicide there the mildew has a chance. Later in the season the application should be directed more to the foliage, for fear of staining the fruit.

As yet, the Chautauqua vineyards have been apparently almost free from other fungous diseases and the advisability of spraying is an open question. During the past season the powdery mildew does not seem to have been sufficiently severe to warrant spraying beyond exceptional cases. What the conditions will be next year it is impossible to say.

C. ANTHRACNOSE.

(*Sphaceloma ampelinum.*)

Upon certain varieties, as Moore's Diamond, Brighton and others, anthracnose is sometimes very severe. It attacks the green stems, leaves and fruit, and sometimes causes a total loss of the crop.

The first indication of the disease upon the stems is the appearance of small dark brown or black spots, sunken in the central portions. These spots enlarge, generally extending up and down the stem, thus forming oval-shaped areas. Sometimes, however, the disease encircles the stem in such a manner as to girdle it and the result is similar to that which would occur if the girdling had been due to some other cause. This form of the disease is particularly prevalent upon the stem of the grape cluster. Here it is sometimes called "ring-around." As the disease progresses, the central portion of affected areas becomes more sunken and finally assumes an ashen color, only the edges of the affected part retaining the dark color.

On the fruit, the first stages are similar to those in the stem. The affected part is, however, often surrounded by a band having a reddish tinge and the center does not always assume the same ashen color, but it remains rather a dark brown. The diseased surface is quite smooth, and sometimes measures a quarter of an inch in diameter. If the berry is attacked while young, or if attacked in several places when grown, it is of no commercial value.

Anthracnose of the grape is the most obstinate disease which the New York vineyardists have to combat. No authenticated cases are on record showing that the disease has been successfully treated by the use of the Bordeaux mixture or of any other fungicide after the foliage has expanded. In fact, I do not know of a single case in which the disease has been kept under control in this state, whatever the method followed.

The anthracnose of the grape is probably of European origin. It was introduced into this country fifteen years ago or more, and has since spread into most sections in which grapes are grown. In Europe it has long been successfully treated, but whether the same remedies will answer equally well in this country still remains to be seen. The following is the method commonly employed by the foreign vineyardists:

Early in spring, just before the buds begin to swell, the arms and canes, including the buds, are treated with a solution made of sulphate of iron (copperas), sulphuric acid, and water in the following proportions:

Sulphate of iron,	110 pounds.
Sulphuric acid (commercial),	1 quart.
Water (hot),	26 gallons.

Care must be taken first to pour the acid upon the sulphate of iron crystals, and only then the water may be added. Otherwise there is danger of the water and acid being spattered when the two come in contact. This solution should be used the day it is made, for the iron sulphate will re-crystallize upon cooling if the liquid is allowed to stand any length of time.

Owing to the caustic properties of this solution it cannot be applied with our common spray pumps. The method followed in France is to tie a bundle of rags at one end of a stick and with this swab the vines are carefully treated. All portions of the vine that are covered turn black and in case the work has not been well done another application is made, but only the light-colored portions then receive attention.

The principal objection to this remedy is its expense and this will prove a serious drawback to the adoption of the method in this country. The vines can scarcely be injured by the application for I have used a similar solution which contained ten per cent. of sulphuric acid upon swelling buds, to the injury of about one-half of them. This remedy will be given a further trial and reported upon.

PART II—IN CENTRAL NEW YORK.

ANTHRACNOSE.

POWDERY MILDEW.

SHELLING.

These troubles are found to a limited extent in central New York, but the conditions are so similar to those in Chautauqua county that what applies to one region will apply to the other also. But other diseases have also been present this year and they will be briefly discussed.

D. BLACK ROT.

(*Læstadia Bidwelli.*)

Black rot was very prevalent in the vineyards situated on the banks of most of the lakes of central New York. Some untreated vineyards lost from fifty to seventy-five per cent. of the crop from this disease, and even some treated vineyards showed a large amount of worthless fruit. Some vineyardists have said that the more the vines were sprayed the worse the rot became and many feel discouraged over the results of the season's work.

The black rot fungus attacks the berries most severely. Upon them it first manifests itself, generally when the berry is about full grown, by producing a brown or purplish spot upon one side. This color gradually extends over the entire berry and in the course of a few days the surface assumes a uniform dark brown appearance, which is deeper, however, in the portion first affected. This part begins to turn darker and produces many small, black pimples, these being a very characteristic feature of this disease. The berry now begins to shrink and dry, but it remains hanging on the stem until late in the season, sometimes throughout the winter.

"In the leaf the fungus causes well defined reddish brown spots of varying size, usually rounded in outline, and dispersed on the parts between the principal nerves. These spots usually appear some days or even a week or two before the berries are attacked. On the young shoots and leaf stalks it effects characteristic changes in the form of elongated, very dark brown or black spots, which are slightly depressed owing to the absorption of the juices from the cells composing the underlying tissues, over the surface of which the characteristic pimples or pustules are more or less thickly scattered."*

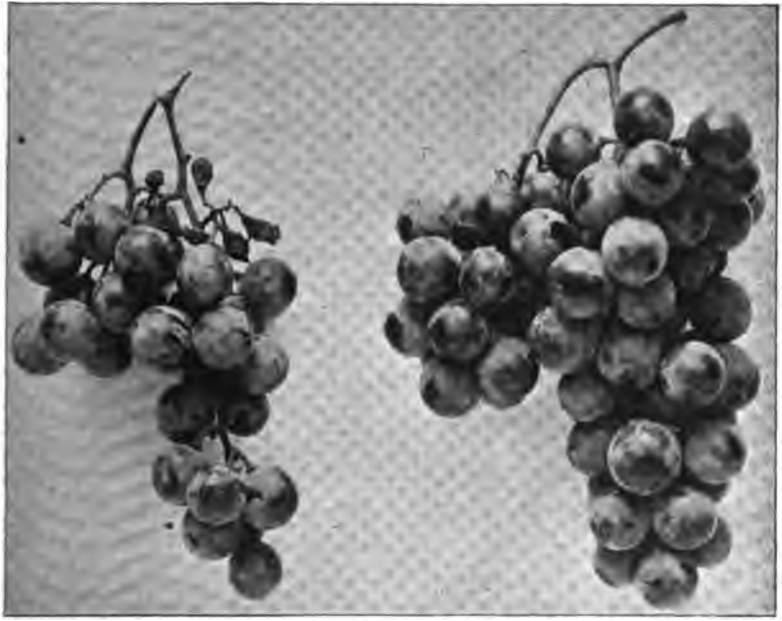

FIG. 5.—*Catawba clusters and black rot.*

Not sprayed. *Sprayed.*

The treatments for the black rot are very similar to those mentioned on page 441. One fact should, however, be kept constantly in mind: the black rot is a very energetic disease and a berry affected with it is ruined. The fungus does not appear until rather late in the season, generally not until the fruit is fully two-thirds grown. This makes later applications dangerous on account of the necessary staining of the fruit. It is therefore

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[*] Scribner. Fungous Diseases of the Grape and Other Plants, p. 10.

essential for the satisfactory control of the black rot that the early application be made *as thoroughly as possible* and upon the same dates as given for the first treatments of the powdery mildew. If the rot is feared, the last applications should be made more frequently, and as long as there is no danger of a permanent staining of the fruit the clusters should be thoroughly treated. The ammoniacal carbonate of copper should be used after the middle of July, or the first of August at the latest. It is better to use the Bordeaux mixture early in the season. The total number of applications necessary to control the black rot varies from three to seven, depending upon the dampness and temperature of the summer months. In warm weather, when the air and soil are kept moist by frequent showers, the disease often spreads with extreme rapidity, and under such conditions the treatment must be repeated every seven to ten days. Among some Seneca lake vineyardists there has arisen the impression that the more they spray the worse the rot becomes. Such a state of affairs is of course impossible. The applications made were probably not followed by as good results as was expected but that must be the fault of the operator and not of the mixture. One cause of this trouble was quite evident. The vines were a mass of foliage, so that it seemed impossible to reach the individual clusters in spraying. The land was also very rich in nitrogen so that the conditions were favorable to fungous growths. The absolute necessity of thorough work cannot be to strongly emphasized. Figure 5 represents two clusters of Catawbas, the one on the left not treated, the one on the right treated according to the above directions. In this case absolute protection was afforded by the spray.

E. BROWN ROT, GRAY ROT.

(*Peronospora viticola.*)

This disease is also caused by a fungus which thrives upon all the green portions of the grape.

It may attack the berries any time during the growing season but is as a rule more serious early in the summer. Diseased berries stop growing and soon becomes covered with a mealy substance which gives them a gray appearance. This has caused the disease to be called a gray rot. When the berries are more advanced at the time the fungus attacks them they turn brown, which has given rise to the name of brown rot, and the gray appearance is not always present. Figure 6 shows two clusters of Niagara grapes attacked early in the season.

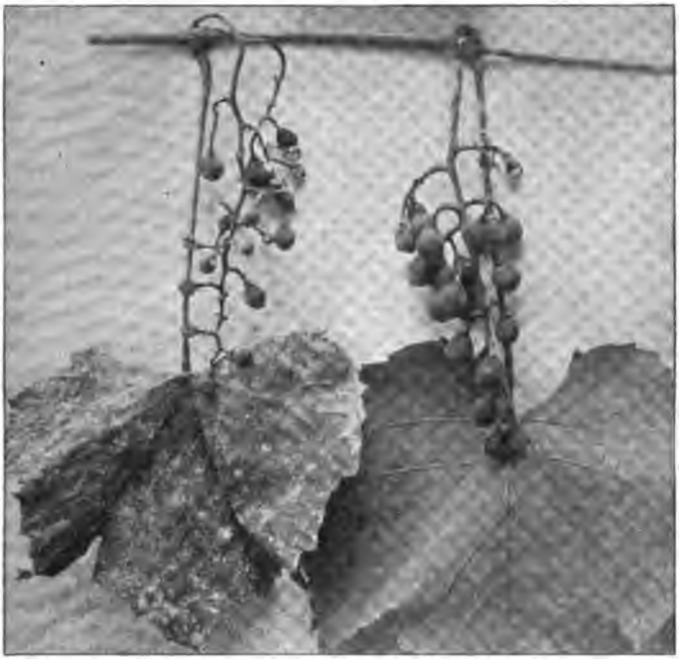

FIG. 6.—*Young Niagara clusters attacked by brown or gray rot.*

The leaves and young shoots also suffer early in the year but the worst time for them appears to be during July. Still I have seen comparatively fresh growth of the fungus as late as October, so that there is danger from the disease so long as there are green portions upon the vine. The fruiting portion of this fungus appears upon the under side of the leaves in the form of gray, downy growths. Directly above these the upper side of the leaves show yellow discolorations which soon turn brown as the affected part of the leaf dies. These areas are quite sharply defined, and the entire leaf does not change color in consequence of such diseased portions.

The stems when mildewed show the same gray appearance on their surface as is seen on the under side of the leaves. In severe cases the fungus kills the stem outright beyond the diseased portion, and a general browning of these parts takes place.

The downy mildew is not so serious late in the season as is the black rot, and this necessitates particular care in making the early applications. The Bordeaux mixture and the ammoniacal carbonate of copper are the safest fungicides to use. The applications should be made as already recommended for the powdery mildew, but greater thoroughness must again be insisted upon, as the disease is more serious than the powdery mildew.

F. RIPE ROT.

(*Glœosporium fructigenum.*)

A disease which to all appearances was the ripe or bitter rot of grapes was seen in some vineyards about Keuka lake. This year the injury done was not serious, but it is evident that the disease exists in this region and it may cause severe losses if the proper conditions for its development are present.

Affected berries change color in the portion first attacked, and this discoloration gradually spreads over the entire berry changing it to a reddish brown. Here the berry remains and shrivels, often hanging to the stem until quite dry, or sometimes dropping to the ground as soon as the shrivelling begins. Pimples appear on the surface of the shrunken portions, but such berries can be distinguished from those attacked by the black rot by their not being of such a black color. They are generally a clear brown or deep purple.*

This disease appears to attack grapes later than does the black rot, which makes it rather difficult to control. But the applications designed for black rot, if thoroughly made, will also check the progress of this disease.

G. DROUGHT.

In several vineyards on the shores of Canandaigua lake were noticed vines which had lost most of the lower leaves from the canes, thus leaving the fruit entirely exposed to the direct rays of the sun. The trouble seems to have begun during the latter part of summer. The leaves turned yellow and then brown, this last color generally appearing in those parts of the leaf situated farthest from the main veins. One-half of the leaf was in some cases destroyed before the other part seemed to suffer. The majority of such cases seemed to occur in portions that were directly exposed to the full force of the sun's rays. Such leaves were more or less curled, or they were so placed that one part shaded another. As a rule, the shaded portion did not suffer much until the part that received the sunlight was very seriously affected. Then the whole leaf gradually yielded to the trouble. The final result was that all the more seriously affected leaves eventually dried and fell from the vines, giving the vineyard a thin and unhealthy appearance.

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* Scribner; *Ibid.* pp. 38, 39.

The cause of the trouble was probably the dry weather, for the thinner the soil and the more it dried out, the worse the trouble seemed to become. Some entire vineyards were injured, others suffered only in certain portions, and those which were upon moister ground did not suffer at all. As soon as the fall rains came, the falling of the leaves immediately stopped.

Any cause which will tend to retain moisture in the soil will lessen the severity of the trouble. The worst case seen was in a Delaware vineyard that had received apparently no cultivation. If a thin mulch of cultivated soil had lain upon the ground, the evaporation would not have been so great and the vines would not have suffered as they did. More expensive and effective remedies can hardly be recommended at present.

PART III—MACHINERY FOR SPRAYING—FORMULAS.

The machinery to use in spraying vineyards and other plantations should be as simple and effective as possible. Three general styles are now in use; knapsack pumps, hand pumps, and power sprayers.

The knapsack pump is probably the most effective, for the spray is entirely under the control of the operator and the work can be done as thoroughly as desired. It is open to the objection of being hard to carry and to work, and it is also very slow.

The hand pump, when placed on the side of a barrel and mounted in a wagon, makes a very serviceable outfit on level ground. It allows the use of two nozzles, and possesses greater power than the knapsack. A good arrangement is to have one man drive and hold one nozzle while the other man pumps and holds the other nozzle.

Power sprayers are the easiest to use, for in them the horse does the pumping. My experience with these has been such that I am convinced that for all low growing plants they are the most satisfactory machines to use. They must be adapted to the work, and be properly built and handled to give the best results. If a good machine is used, the work will be done about as effectively as with a hand pump, and much more easily. Some New York vineyards have been kept practically free from fungous diseases by their use.

The best nozzles for such work are probably the Vermorel, the McGowen, or the Bordeaux. These can be graduated, are easily cleaned, and are durable.

FORMULAS.

Bordeaux Mixture.

Sulphate of copper, 6 pounds.
Quick lime, 4 pounds.
Water, 40 to 50 gallons.

Dissolve the sulphate by hanging it in a bag in the liquid at the top of a wooden or earthen vessel full of water. One gallon of water will dissolve from one to two pounds of the sulphate. The lime should be slaked in an equal volume of water and when the two are ready they can be poured the one into the other and then thoroughly stirred.

Another way of making the Bordeaux mixture has recently come into use. The sulphate of copper is used at the same rate as above but it is dissolved so that every gallon of the solution shall contain one pound of the sulphate. Then for the above formula six gallons would be taken and to this milk of lime is added until the ferro-cyanide of potassium will not discolor the mixture when a drop or two are added to it. So long as there is not sufficient lime present the test will show a dark brown discoloration where the material falls. When enough lime has been added no change takes place. The test solution is made by dissolving about an ounce of the ferro-cyanide of potassium in a pint of water. Only a drop or two need be used at a time, when making the mixture. I should recommend adding more lime than the test shows to be necessary, for from the experience of the past season the Bordeaux mixture has in some cases done serious damage to fruit. This subject will be more fully discussed in a future bulletin.

Ammoniacal Carbonate of Copper.

Carbonate of copper, one ounce.
Ammonia, enough to dissolve the copper.
Water, nine gallons.

The copper carbonate should first be moistened with a little water and the ammonia then added. This stock solution should be kept tightly corked until used. It will keep indefinitely. When wanted, dilute to the required extent with water, and apply.

Iron Sulphate and Sulphuric Acid Solution.

(French, for Anthracnose).

Sulphate of iron, 110 pounds.
Sulphuric acid (commercial), 1 quart.
Water (hot), 26 gallons.

First pour the acid upon the iron crystals and then add the hot water. As soon as the crystals are dissolved the solution is ready for use and should be applied the same day if possible. Do not apply this by means of metal apparatus for the acid will corrode and render it worthless. Apply with a cloth swab, and only to dormant plants.

SUMMARY.*

PART I.

1. The shelling of grapes occurred to a very serious extent in 1890 and 1894. Page 418.

2. This disease is probably not identical with *apoplexie* or with *rougeot*, two diseases occasionally present in French vineyards. Pages 420, 421.

3. Insects do not cause the disease. Page 423.

4. Fungi, especially the powdery mildew, may aggravate the condition to a limited extent, but they cannot be held as the prime cause of the trouble. Page 423.

5. The "blight" or unnatural dying of the foliage is not the cause of the malady, but is probably a manifestation of the action of the same causes which produce the shelling of the grapes. Page 424.

6. The stems shrivelling before the berries mature is another condition produced by the same cause. Page 425.

7. The premature ripening of the berries is due to the same causes as the blight of the leaves and the abnormal condition of the fruit stems. Page 425.

8. The premature ripening of the wood, while it may to a certain extent be the cause of the shelling, can scarcely be considered as the fundamental cause of all the trouble. Page 425.

9. Vines which are allowed to overbear are probably more liable to shell than are those not in the same condition. The weakening of a plant causes it to succumb more easily to unfavorable conditions. Page 425.

10. Too much wood may increase the extent of the trouble, for when the wood ripens it apparently takes its required nourishment at the expense of the fruit. Page 426.

11. Too rich land will scarcely cause shelling provided the

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* NOTE.—The conclusions regarding the shelling of grapes have been drawn almost entirely from one season's observations, and the subject should receive further attention in the future.

available food supply is present in proper proportions for the use of the plant. Page 426.

12. Nitrogen apparently increases the amount o shelling. Lands which are rich in this element of plant food seem to suffer more than those growing in land that makes a smaller growth of wood. Page 427.

13. The shelling of grapes upon soils rich in nitrogen is propably not due to an inherent tendency of the nitrogenous food to produce shelling, but rather to a faulty ratio between the amounts of available plant food. Page 427.

14. The kind of soil, not considering the food supply contained in it, does not appear to exercise any marked influence upon the degree of shelling. Page 427.

15. Too much cultivation seems to aggravate the trouble, probably on account of the larger amount of nitrogenous food liberated by the operation. Page 427.

16. Excessive drought alone cannot be held as the sole cause of the trouble, although it is probable that the dry weather caused the loss to be greater than it would otherwise have been. Page 428.

17. Excessive rains after a prolonged drought may have influenced the severity of the shelling but to what extent is not known. Page 429.

18. A weak root system would have an effect upon a plant similar to that exercised by allowing it to overbear, and a like tendency towards shelling would exist. It seems probable from the fact that young vines, as a rule, shell the most, that the limited root system may be in part responsible for the trouble. Page 429.

19. A want of barnyard manure has been ascribed as a cause, and the trouble, in one case, has been stopped by its use. Page 431.

20. No evidence at hand goes to show that shelling is due to a want of phosphoric acid. Page 431.

21. Many vineyardists have apparently stopped the shelling by applications of potash. Page 431.

22. Potash seems to be the food required by the plant in the majority of the cases in which the vines shell and it may be wanted in all cases. Page 432.

23. The principal reason for this lack of potash is undoubt-

edly the continuous cropping to which most of the shelling land was submitted before the vineyards were set. Page 432.

24. Excessive heat of itself did not cause the shelling. Page 435.

25. A warm wind, one which would have a tendency to excite active growth, might have a tendency to increase the shelling. Page 435.

26. A cool wind or cool weather, on the contrary, may stop the trouble to a considerable extent. Page 435.

27. Powdery mildew was quite prevalent in Chautauqua county in 1894, but it is certain that the usual remedies will check the disease. Pages 436, 441.

28. Anthracnose is serious in some localities and it is recommended that growers make a trial of the acid sulphate of iron solution, as described on page 443.

PART II.

29. Shelling, anthracnose, and powdery mildew exist also in the lake region of central New York. The remedies already mentioned are recommended.

30. Black rot, brown rot, and ripe rot appear to have done some injury in this region during the past season, and the usual remedies are recommended. Pages 444, 446, 448.

31. The failure of some vineyardists to prevent these diseases was probably owing to a too heavy growth of foliage, and to improper methods of making the applications.

32. Drought caused some vineyards to suffer severely. Shallow and frequent cultivation is probably the most practical method of counteracting this influence. Page 448.

PART III.

33. A knapsack sprayer is the most effective machine, but it is the hardest to work and the slowest in covering the plants. Page 450.

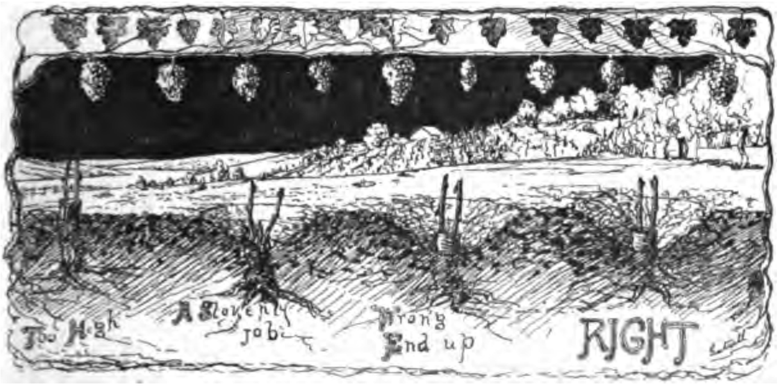
34. Hand pumps allow of much more rapid work, but the work is not always so effective. Page 450.

35. Power sprayers, under favorable circumstances, are the most desirable machines for spraying vineyards. Page 450.

E. G. LODEMAN.

Bulletin 77. **November, 1894.**
Cornell University Agricultural Experiment Station.
HORTICULTURAL DIVISION.

THE
Grafting of Grapes.



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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.

CORNELL UNIVERSITY, ITHACA, N. Y., Nov. 6, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir:—The average yield of grapes in western New York in good years is one and three-fourth tons to the acre. This is half or less the yield of the best vineyards. This low average is due to many causes, but one of the chief is the persistent growing of unproductive varieties. The most ready means of correcting this fault is to graft the unprofitable varieties, but growers are, in general, ignorant of the process. The following account, therefore, drawn from our own experiments, and from the experience of vineyardists in western New York, is prepared for the purpose of supplying this information; and it is submitted for publication and distribution under section 87, chapter 675, of the laws of 1894.

L. H. BAILEY.

THE EXPERIMENT STATION EXTENSION, OR NIXON, BILL.

A law was made last winter appropriating $8,000 to be expended by Cornell University for the benefit of horticulture in the Fifth Judicial Department of the State—an area comprising the counties of Cayuga, Seneca, Yates, Steuben, and all counties to the westward. This fund is to be expended "in conducting investigations and experiments in horticulture; in discovering and remedying the diseases of plants, vines and fruit trees; in ascertaining the best means of fertilizing vineyard, fruit and garden plantations, and of making orchards, vineyards and gardens prolific; in disseminating horticultural knowledge by means of lectures or otherwise; and in preparing and printing, for free distribution, the results of such investigations and experiments, and such other information as may be deemed desirable and profitable in promoting the horticultural interests of the State." All this work is to be prosecuted by Cornell University "under the general supervision and direction of the Commissioner of Agriculture."

This bill became a law so late in the season, that few particular lines of experimentation could be attempted which should give results the present year. But an effort has been made to complete a somewhat thorough survey of the horticultural industries of the Fifth Judicial Department, and the results of this undertaking are now appearing in bulletin form. Bulletins 69, 70, 71, 72, 74, 75, 76 and 77 belong to this series, and others, so far as the fund will allow, are forthcoming. It is hoped that these reports, by discovering and recording the present state of the interests of which they treat, may form the basis for exact experimentation, if such is desired in the future. Every good farm is, in an important sense, an experiment station, but its teachings, in order to be valuable and of use to the commonwealth, must be studied by a trained and disinterested observer. Such results, when published, are of inestimable value, because they arise from normal and practical conditions; and they inspire a confidence and sympathy which investigations conducted at a central experiment station can scarcely hope to awaken.

Yet, certain experiments are already well under way. Somewhat extensive investigations of the actual fertilizing of orchard lands are progressing in various parts of western New York; and about 500 acres of fruit plantations have been sprayed directly or indirectly through our efforts, and the results have been subjects of careful study. Aside from these, many special experiments are in progress in the interest of the law, the precise nature of which will appear as the investigations mature. It should also be said, that an important feature of the operation of the Nixon law, is the opportunity which it extends to every horticulturist in the Fifth Judicial Department to have his particular difficulties investigated, and to receive direct advice from persons who are expert in particular directions.

In order to fully secure the benefits of the law, it is necessary that horticulturists freely coöperate with us in the way of furnishing information, in allowing us the use of plantations for study and experiment, and in laying before us the difficulties under which they labor.

L. H. Bailey, *Officer in Charge*,
Ithaca, N. Y.

GRAPE GRAFTING.

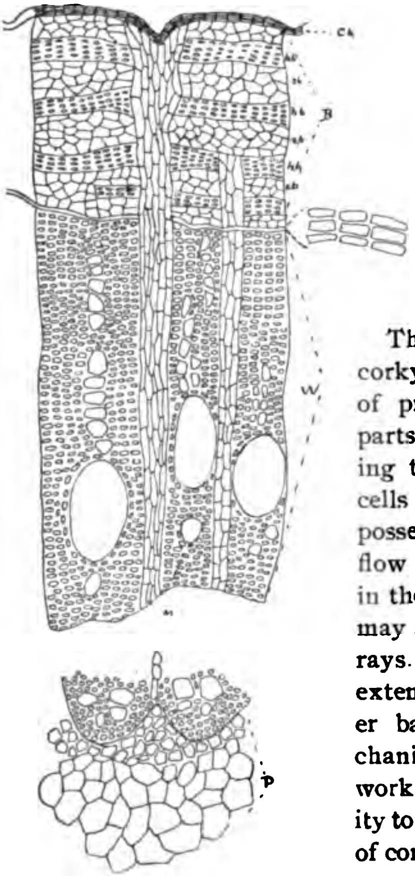
INTRODUCTORY.

The grafting of grapes is a subject which is increasing in importance as grape growers become more familiar with the varieties which are now growing in their vineyards. Many bearing vineyards are not giving such satisfactory returns as were expected and in many cases it is often largely owing to the fact that the proper varieties have not been selected. Or a certain district may be especially adapted to the growing of particular varieties, and it seems to be desirable to alter vineyards now in bearing so that they will produce the desired fruit without the loss of time which would result from tearing up the old plants and setting new ones. These and similar causes have forced vineyardists to turn their attention to the grafting of their vines, and several have already done considerable work of this character. In this article herbaceous, or soft wood grafting, will not be considered, as it is rarely used upon the grape. Various experiments upon a practical basis have been made during the past two or three years by the writer and his former associate, L. C. Corbett, now professor of horticulture and forestry in the Agricultural College of South Dakota.

Structure of the stem.—Hard wood grafting is not a difficult operation when a few essential points are observed. From ninety-five to one hundred per cent. of the grafts should grow when the work is carefully done, and skill in performing the operations is soon acquired.

Figure 1 represents a cross-section of the stem of a grape, and an understanding of the general character of the different parts will assist in explaining the reason of the successes as well as of the failures which will occur with all operators.

The corky external layer (c k) as well as the bark (B) immediately underneath it are composed of cells which have ceased to grow. The same may also be said of the cells of the wood (W), of the medullary rays (M), and of the pith (P). Those forming the pith are perfectly inactive and have no practical value in the economy of the plant. The wood of the grape serves as a medium for the passage of large quantities of water or crude sap. In these cells the general tendency of the movement is upward.



1. Cross section of a grape cane, much magnified, to show the structure. c k, cork. s b, soft bast, h b, hard bast. B, bark, C, cambium. W, wood. P, pith. M, medullary ray.

The office of the bark and of the corky layer is probably mainly one of protection to the more delicate parts beneath. The cells composing them, excepting the soft bast cells (s b), are also inactive, and possess apparently no life. The flow of liquid, if it ever takes place in them, is very limited. The same may also be said of the medullary rays. The use of these woody cells, extending from the pith to the outer bark, seems to be largely mechanical, for they serve as a framework which is designed to give solidity to the stem, and also as a medium of connection between the inner and outer parts of the stem.

One part of the diagram, that marked (C), still remains to be discussed, and it is this portion which is of the greatest interest to those who graft plants. This layer of cells or cambium, as it is called, is that part of the stem which contains the living or growing cells. In the main part of the drawing it is represented simply by two parallel lines. But at the end of these lines to the right the structure is represented still more highly magnified. It is here seen to be composed of three rows of cells running in a direction parallel to that of the bark. The number of these rows varies at different times of the year, there being many more during the period of active growth.

Office of the cambium.—It will be noticed that the cambium layer separates the wood from the bark. An interesting feature of this layer is that after division the cells next the bark go to the formation of bark, while those nearest the wood form woody fibre, yet the origin of the two is the same. We may suppose the cells of the central row to be divided into halves by a vertical wall. One half will then go to the formation of either wood or of bark, as the case may be, while the other half remains to increase in size and to divide as before. Thus the origin of both the young bark and of the young wood is probably in a single row of cells situated between these two parts of the stem, and it is largely in this layer that active growth in our common woody plants takes place.

From the above it will at once appear that no union will take place between stock and cion unless the living cells, or the cambium layers of the two, are placed in close contact, and no grafting can be successful where these conditions are not complied with. Some plants appear to be more exacting in this respect than others, and the grape, fortunately for the careless vineyardist, is not so particular as are many of our cultivated trees and shrubs. It will undure a certain amount of careless work and still effect a union.

This fact should not encourage poor or hasty workmanship. All tendencies which lessen the chances of success deserve to be studied so that they may be avoided. No sand or dirt should be allowed to rest upon cut surfaces, if it can be helped, until after the parts are placed in position. Such particles would prevent to a greater or less degree the intimate contact of the two surfaces. All cuts should be made as smooth and as straight as possible so that no projection of wood will prevent the two layers from pressing against each other.

It is not essential to success that the cambium layer of the two parts be in contact at every point. Such a result is almost impossible in practical work, and it is especially so in grapes where large stocks are being worked, for in them the grain is generally considerably twisted. But in order to insure success the layers should come together in at least one point. This will be enough to insure the "taking" of the graft, but the growth may not be very strong, and the union will naturally be rather weak for the first year or two. If the cambium layers are in proper condition and in close contact for a considerable distance, a strong union and a vigorous growth will result.

Condition of cion and stock.—The condition of the cion and of the stock must also be considered, for it is of the greatest importance that these should be in a proper state as regards the comparative activity of the cambium layers. The cion should in all cases be dormant or practically so. If it is not dormant the cambium cells will have become accustomed to a certain supply of sap, and any serious reduction in this supply will be followed by a check which may be fatal. Such a check would take place if an active stem be cut and inserted upon a stock that is unable to supply the accustomed amount of nourishment; or even if the sap of the stock is in active flow the comparatively slight transfer of material which could be made immediately after an operation would be insufficient to supply the demands of the cion.

The stock may be more or less active, however, at the time of the grafting, provided the cion be inactive. A dormant cion requires but little nourishment, and if the stock satisfies these needs that is all that is required. The operations should be successful provided the flow from the stock is not so heavy that the cion will be "drowned out." Such a flow occurs while the first growth in spring is taking place, and cions should be inserted either before it begins or immediately after the most energetic action has ceased.

Seasons for grafting.—Grape grafting may be performed in the fall, early in the spring before the heavy flow of sap begins, or during late spring when the sap is no longer so active; opinions are divided as to which is the best season of the year. If the work is done in the fall, the time for the uniting of the two portions before active growth begins is very long and on this account the chances of success are better. But the danger of accident during the winter must be taken into account to offset this advantage. When the grafts are made below ground, as is commonly done, there is danger of the cion being heaved out by the frost, or at least of being misplaced to such an extent that no union will take place. Soils which heave the most will be apt to do the most damage. Winter protection is essential to success and where it is given, good results should follow. The protection may consist of burying the cion completely after the graft has been made, or a heavy mulch of some material, as straw, leaves, etc., will answer. Such a covering will prevent the alternate thawing and freezing of the soil, which is sure to result in more or less injury to the graft. A. S. Fuller recommends* grafting grapes "in the fall, after the leaves have fallen, and any time before the ground is frozen, say in October, November or December, varying according to the latitude." His grafts are made below the surface of the soil and are protected very carefully from frost. This is done by placing an inverted flower-pot, sufficiently large for the purpose, over the cion, having the bottom of the pot on a level with the surface of the soil. The excavation is then filled with earth but the bottom of the flower-pot is left uncovered. Then all is covered with about six inches of straw and over this is placed soil to the depth of about eight inches. When so protected, the grafts pass the winter in excellent condition and start off vigorously in the spring.

The majority of those who have had practical experience in the grafting of grapes seem to agree in saying that early spring is the most suitable time for performing the operation, all things considered. The graft should be inserted before the flow of sap has begun, and the first warm days in March are the ones which are well suited to the work in a great many seasons. On the whole, the earlier in spring that the grafts are inserted the better are the chances of success, as more time is allowed for union to take place. Much depends upon the season, but generally March will offer some periods in which the vines can be worked. It is but a short time after the frost is out of the ground before the vines will bleed considerably when cut, so the work must be done before the season becomes far advanced.

The third period in which grapes may be successfully grafted is late in spring, or as soon as the vines have made a growth of eight or ten inches and the first heavy flow of sap has ceased. The principal objection to this season is the difficulty of obtaining suitable cions. These should be cut while perfectly dormant; they should then be packed in some damp material as sand, sawdust, moss, etc., and placed in as cool a position as can be found. This is done to retard all growth until the cions are inserted. When the grafting is done in the fall or early spring the wood is in suitable condition for use, and it may be cut as wanted. But for late spring grafting the wood must be cut and stored in an ice house if possible, although open ground in some well shaded spot will also answer fairly well.

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* Fuller, The Grape Culturist, 1867, p 66.

It will be noticed that in the methods of grafting described in the following pages only those are mentioned in which the cut surfaces of the stock are all below the level of the ground. My experience with grafting grapes above ground* has been such that I cannot recommend it, except for particular purposes. Much better results are obtained when the cions are inserted low enough so that they may be partially or wholly covered by moist earth. The work is then done under certain disadvantages, but the successes are so much greater that they more than make up for the extra trouble:

METHODS OF GRAFTING.

On Established Plants.

No. 1. Cleft graft.—This form of graft is generally made by sawing off the vine from three to six inches below the surface of the soil, leaving a stub into which one or two cions may be inserted, as shown in Fig. 2. The saw used should be sharp so that it will work easily and not lacerate the edges of the stub. When much grafting is to be done it might be a matter of economy to have a saw made especially adapted to the purpose. The handle should be on a higher plane than the blade; this allows the free use of the hands above the ground while the blade is below, near the bottom of the excavation made about the stem of the vine. If a common straight saw is used, the stock must be cut off at an angle or the hole must be made larger, neither result being exactly what is desired. The blade need not be more than six or eight inches long, and only wide enough to give it firmness. The handle, which can be of any convenient pattern but large enough to be grasped by both hands, should be attached to a solid bent shank having the part which lowers the block into the excavation from three to four inches in length.

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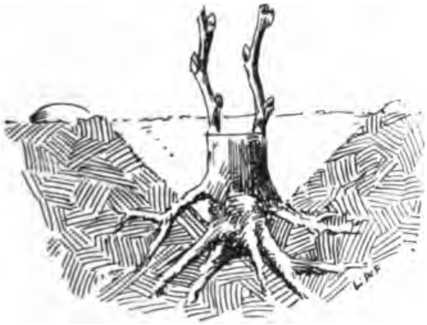
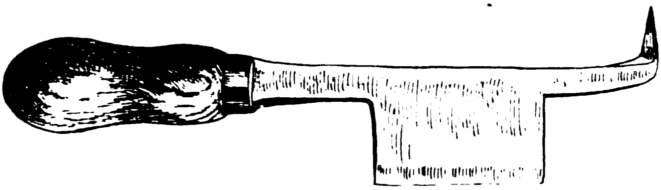
* For an account of some experiments conducted in 1891 with reference to this point see *Garden and Forest*, v. p. 498.

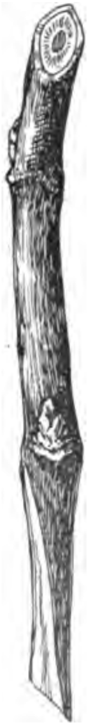

2. *Cleft grafting.*

When the stock has been sawed, it is a good plan to smooth the top of the stub, at the places in which the cions are to stand, with a sharp knife in order to dress those portions of the sawed surface and to show more distinctly the line dividing the bark from the wood.


3. *Grafting knife for splitting stubs.*

The next step is to split the stub, leaving the smoothed parts above mentioned at the top of the cleft. This splitting of the stub is not such an easy matter as at first appears. A tool commonly used for this purpose is shown in Fig. 3. It is made very strong so that there will be no danger of its breaking when driven into the stub. A large chisel might answer the same purpose. The cutting edges should be sharp to prevent unnecessary tearing of the cells. The grain of grape wood is by no means very straight and some varieties seem to have a peculiarly twisted wood. In such cases a keen edge upon the tool is of great value. It has been recommended to use a fine saw for making a cleft to receive the cions; in many cases this advice is well worth following for it is practically impossible in some instances to split a stub in such a manner that a cion will have much chance of growing.

When the stub has been split or sawed to a depth of about two inches it is then ready to receive the cions. These should be prepared as shown in Fig. 4. They should carry at least two buds, and short-jointed wood may carry three. The cuts which form the lower end of the cion into a wedge should begin a little below and on each side of the lower bud. The wood should be cut so that the edge opposite the bud shall be thinner than the part under it, as is shown in the illustration. These cions may be prepared in this manner before taking them to the field, but care must be taken that the cut surfaces do not become dry. This may be prevented by packing them in some clean material as moss or moistened cloth. When all is ready for the insertion, the wedge which projects at the end of the grafting knife, Fig. 3, is driven into the central portion of the cleft until the space is large enough to receive the cions. These are then carefully inserted, not in a direction parallel to the central axis of the stub, but at a slight angl with it, allowing the tops of the cions to lean a trifle away from the stub and from each other. The reason for this inclination is to make sure that the cambium layers of cion and stock cross at one point at least. The greater the angle of the cion the shorter will be this place of contact; therefore, care must be taken that the cions diverge but slightly. When both cions are in position, the lower bud, having been placed on the outside, the wedge is carefully withdrawn. As the cleft in the stub closes, pressure is brought to bear upon the grafts; but since these were cut so that the portion under the lower bud is thicker than the part opposite to it, the pressure is greater at the outer side of the cion. This is where it is wanted, for the cambium layers are brought into very close contact and if the work has been well done success is practically assured. In case of large stubs, the pressure in the cleft may be severe enough



4. *Cion.*

to injure the graft. When the cion is being squeezed so that its form is altered it is well to insert a wooden wedge in the cleft to relieve this excessive pressure.

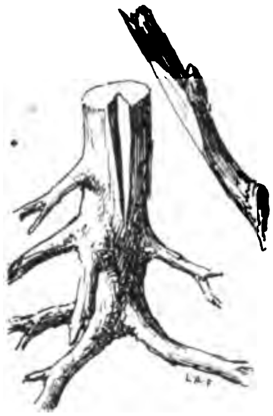
All that now remains to be done is to fill the cavity about the stub with earth, and the cion should also be buried so that only about an inch, or the part above the upper bud, remains uncovered. The soil should be firmed slightly to prevent it from drying out, and the operation is finished. Wax is sometimes used to cover the cut surfaces of both cion and stock, but I have never been able to see that any advantage was obtained from its use that the earth did not grant equally well. Some have gone so far as to say that its use is positively injurious, so when the grafts are placed below the surface of the soil the use of wax is not recommended.

The growth made the first season by such grafts is frequently very large, and enough wood is formed and a sufficiently strong union made to support nearly a full crop of grapes the next year. If the operation is well done, therefore, only one season is entirely lost and but a small part of the crop of the second.

No. 2. Cleft graft on a partially severed vine.—This form of graft differs from the preceding by not having the vine completely cut off. A horizontal cut is made only about half way through the stock, and then another cut is made, beginning from one to three inches above the horizontal cut, and sawing inwards and downwards so that a wedge-shaped piece is removed from one side of the stem. The length of the downward cut should be about one and a half times as long as the horizontal cut, in order to allow the cleft to be made more easily. The manner of inserting the cions is identical with that already described.

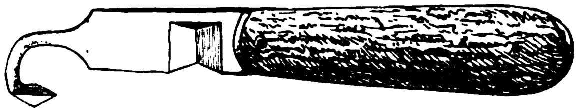
The advantage of this form of graft is that if the cions die the original vine is not lost, but will continue to bear. The yield may be smaller, yet some crop is harvested whether the cions die or live. In the latter case the old vine is pinched backed so as to throw more sap into the grafts. The second year the old vine is reduced still more and at the end of the year may be cut away entirely, thus allowing the cions to take its place. In this manner but a comparatively small loss in yield is sustained.

No. 3. Crown graft by inlaying.—Figure 5 represents the stock prepared for this form of graft. The stock is cut as for cleft grafting. In place of splitting the stub, two V-shaped grooves are made on opposite sides of it. These grooves are made by means of an instrument especially designed for the purpose. It is shown in fig. 6. The tip cuts out the triangular part as shown in the illustration. In the blade itself is a part which is bent at the same angles as the parts forming the tip. This indented portion of the blade is used for cutting away the end of the cion, and with very little practice an almost perfect fit of the two parts can be made. The two cions are then placed upon the stock and are firmly tied there. The tying material should be of such a nature that it will decay before there is any danger of strangling the cions. Raphia does very well, as does also bast. I have also used No. 18 knitting cotton, soaked in boiling grafting wax, with entire satisfaction. The ligatures should be made as tight as possible.



5. *Crown grafting by inlaying.*

Although this method of grafting is not so commonly used as others, it still possesses some decided advantages. It is a much simpler and more satisfactory method than cleft grafting in very curly wood. The tying is a slow process, and for straight-grained wood the cleft graft is to be preferred. It is also open to the objection of requiring the shoots to be staked or tied to some support, for the wind is apt to break the point of union more easily than with other methods. A good union admits of a very strong growth, and if the above precautions are kept in mind the vines will equal those produced by either of the preceding methods.



6. *Grafting knife for inlaying.*

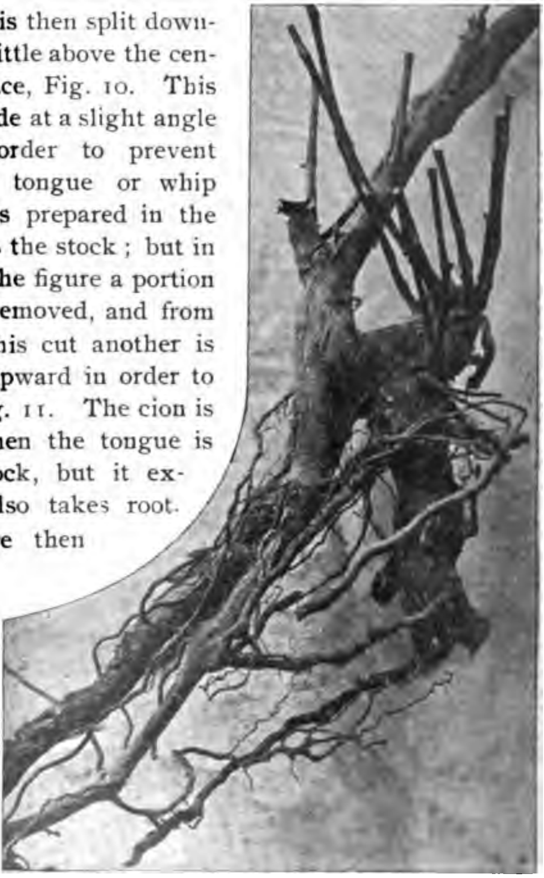
No. 4. Cutting graft.—Figure 5 also shows a cion prepared for another graft. The only difference between this and the preceding is that the cion is made very long. One side near the top is cut in the form of a wedge which fits snugly into the V-shaped cut in the side of the stock. The lower part of the cion projects downward and outward for ten or fifteen inches This lower portion also takes root and under favorable circumstances an enormous growth can be made the first year. One plant in the vineyard of J. W. Corbett, near Watkins, N.Y., upon which a Niagara cion had been inserted in this manner, made a total growth the first season of

7. *The first season's growth of a cutting graft.*

fully seventy-five feet (Fig. 7) and the next year it bore about fifty clusters of grapes. The stock was Red Wyoming, six years old. Figure 8 shows such a union one year from grafting. This is a more certain form of graft than No. 3, and although more tedious is still to be recommended as one of the safest methods. The cion is the portion running down the left side of the picture.

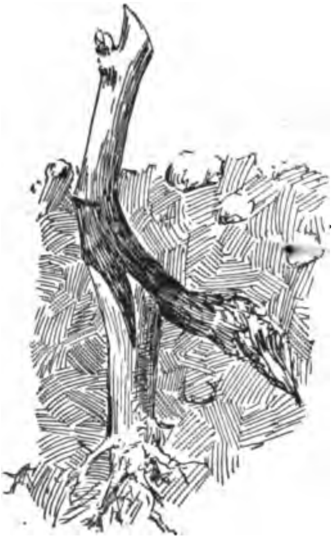
The sprouts which have started from the stub should be kept down in this as well as in other forms of grafting, but they appear to be particularly abundant when this method is followed.

No. 5. Modified tongue graft.—Figure 9 represents a form of grafting which is quite common in Italy. The stock is cut off at an angle an inch or two below the surface of the soil and is then split downward, beginning a little above the center of the cut surface, Fig. 10. This downward cut is made at a slight angle to the grain in order to prevent splitting. In true tongue or whip grafting the cion is prepared in the the same manner as the stock; but in the graft shown in the figure a portion of the bark is first removed, and from the lower end of this cut another is made inward and upward in order to form the tongue, Fig. 11. The cion is not cut in two when the tongue is made, as is the stock, but it extends below and also takes root. Cion and stock are then united as shown in Fig. 9, care being taken to have the cambium layers in contact on one side. When cuttings or parts of equal diameters are grafted by the tongue graft, the layers on both sides may be placed together. The tying of grafts is advisable when small wood is used, but large stocks, when cut below the ground, scarcely require this precaution. When the operation is finished, the soil is heaped up as in cleft grafting.

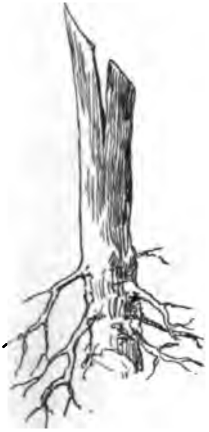


8. *Cutting-graft one year old.*

In California* the tongue graft has gained considerable favor for large as well as for small stocks. In case the stocks are large, they are pared down so that the part upon which the cion is inserted is not much wider than the cion itself. When the two parts are in position, the graft is firmly tied with strips of common calico about an inch wide and ten inches long. The estimate of the cost of the operation is given at three cents per vine, this including the second grafting of those which failed to grow the first time.

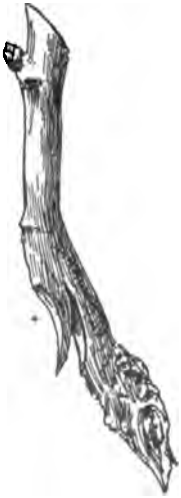


9. *Modified tongue graft.*



10. *Modified tongue graft, prepared stock.*

No. 6. Side graft.—This method possesses an important advantage, already spoken of under No. 2. The stock does not need to be cut off in order to insert the cion. A cut is first made inward and downward in one side of the stock at the same distance under the surface of the soil as for the other methods named. For making this side cut, a tool shown in Fig. 13 is very useful. The shaft is bent so that it can be easily held, and the lower end is made comparatively thin so that the wood will not sliver much when the cutting edge is driven in. An ordinary chisel if well sharpened may answer the same purpose, but not so well. The tool should be driven in from one to one and a half inches.



11. *Modified tongue graft, prepared cion.*

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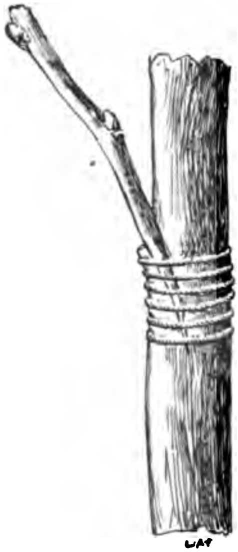
* Leonard Coates, Report of the Sixth Annual State Viticultural Convention, 1888, p. 50.

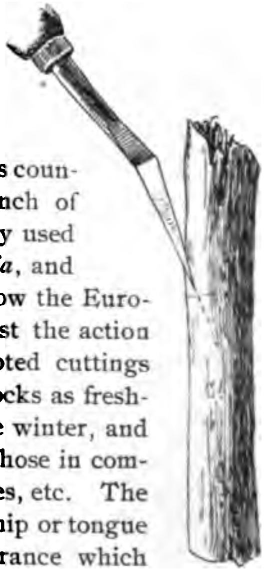
The cion for this graft is easily made. The lower end is cut in the form of a simple wedge, and it is then pushed into the cut in the side of the stock until all the cut surfaces of the cion are covered by the lip of wood on the stock. Figure 12 shows the manner of insertion; it represents the upper end of the lip as being removed, but this is not necessary. After the cion is inserted, taking care to have the cambium layers as nearly in contact as possible, the stock is firmly bound. The cavity is then filled with earth and the operation is finished. As the cion grows, the old vine should be pinched back so that the nourishment may go to the formation of the desired top.



12. *Side Graft.*

On Cuttings.

No. 7.—Figure 14 shows a rooted cutting on which has been grafted a cion by means of the cleft graft. It represents a class of grafts which, though as yet of little practical importance in this country, is in Europe a very important branch of grape propagation. The stock commonly used there is the strong growing *Vitis riparia*, and the operation is performed in order to grow the European varieties upon roots which will resist the action of the root louse, or phylloxera. Rooted cuttings are perhaps not so commonly used for stocks as freshly cut wood. The grafting is done in the winter, and the methods followed are very similar to those in common use here for the root grafting of apples, etc. The splice graft is often used, as well as the whip or tongue graft. Machines have been made in France which sort the cions and the stocks so that only those having equal diameter are united. This increases the chances for a successful union.

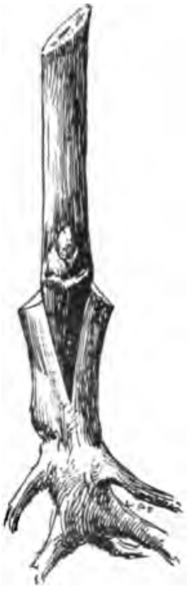


13. *Tool for making incision for side graft.*

After the two parts are placed in position, they are firmly tied with waxed twine and packed in damp material until spring. They are then set out in nursery rows and allowed to grow one season. The following year they are set in vineyards, although in some cases this is done directly, instead of putting them first in the nursery. The grafts are planted so that the point of union between cion and stock shall be on a level with, or a trifle below the surface of the soil. The earth is then heaped around the cion leaving only the upper bud exposed.

This method of grafting may become of value in this country for the purpose of having weak growing varieties upon vigorous roots. The field is so new that one can scarcely predict what will be the results which may follow from grafting one variety of grape upon another.

Figure 15 represents a successful graft seven years old when photographed. The operation was performed by B. P. Olin, North Hector, N. Y. He inserted a cion of Brighton upon a four-year-old Agawam stock, and so perfect was the union that not an external trace remains to show where the two parts are joined. The point of union is on a line directly between (*a*) and (*b*), as could be seen when the stock was cut. Under such favorable circumstances there is no reason to suppose that grafted vines are not as long lived as those upon their own roots, provided suitable varieties are selected.



14 *Rooted cutting cleft grafted.*

No. 8. A peculiar method which has been employed in grafting cuttings is shown in fig. 16.* The description is here given in full:

"The following method of propagation has done well where I had a new variety that I wished to multiply rapidly. In taking up vines in the fall, when clipping back the roots, I save bits of them about a quarter of an inch in diameter, and keep them in damp sand until needed. In February or March I cut these roots in pieces two inches long, using a piece to each graft, as in apple root grafting, but instead of that method cut the upper end of the piece of root wedge-shaped and inserted it in the lower part of the graft as shown in the illustration (Fig. 16). If the wood is long jointed I use one eye to the graft; if short, two eyes. Tie the grafts firmly with waxed thread. The root gives the graft-eye a start, and by fall I have a row of them average three feet in growth.

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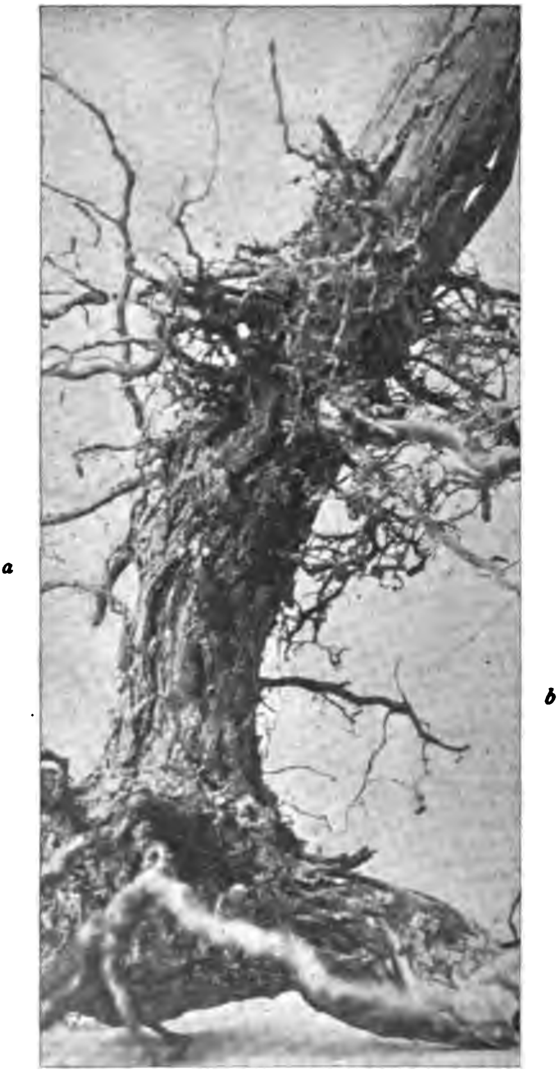
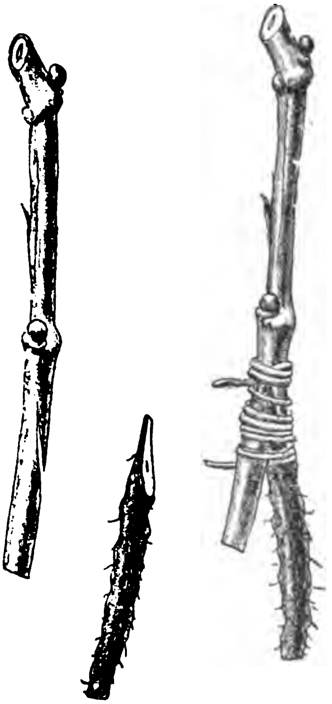
* Samuel Miller, *American Gardening*, September, 1892, p. 535.



15. *A successful graft seven years old.*

"These grafts can be placed upright in boxes of sandy soil and left there until they have started to grow. If you can give them a little bottom heat it will be a great help. Accustom them to plenty of air and sunshine before setting them out in the open ground, plant them late in the afternoon, and shade them for a few days. The grafts soon callus at the lower ends and emit roots of their own."

Although the above graft appears to be very successful, the work and care required for its execution will probably prevent its genreal use. It might properly be called an inserted side graft, and it is probable that if the grafts are made early enough in the winter, union would take place before active growth begins, and less care be necessary to insure success.



16. *Inverted side graft for cuttings.*

SUMMARY.

1. The living or growing cells in the stem of the grape are largely in the cambium layer. Page 460.
2. A union between cion and stock will not take place unless the cambium layers are in close contact. Page 461.
3. The grape is not difficult to graft, but the operations must be carefully performed. Page 461.
4. The cion should be dormant or practically so at the time of insertion. Page 462.
5. The stock may be dormant, or the sap may be active, but the heavy flow of sap which occurs in spring should be avoided. Page 462.
6. Grapes may be grafted in the fall, early spring, or late spring. Page 462.
7. When the work is done in the fall or winter, protection must be given in this latitude. Page 463.
8. Early spring is on the whole the best time for grafting grapes, and the earlier it is done the better. Page 463.
9. Cions inserted late in the spring will unite with the stock provided they have been kept dormant. Page 464.

10. Grape grafting will be followed by better results if the cions are inserted below the surface of the ground. Page 465.

11. Cleft grafting is the most common and perhaps the most successful form of graft to use, but it necessitates the entire removal of the top. Page 464.

12. Cleft grafting on a partially severed vine does not require the complete removal of the top, and under similar conditions offers nearly as good chances of success as when the ordinary cleft graft is used. Page 467.

13. Crown grafting by inlaying is a more difficult operation than cleft grafting, but it offers the advantage of being preferable when the wood of the stock is curly, and does not split readily. Page 468.

14. Cutting grafting is a more difficult and tedious method, but is followed, when well performed, by exceptionally vigorous growth. Page 468.

15. Tongue grafting, as practiced by the Italians or by the vineyardists of California, gives excellent results both upon large and small stocks. Page 470.

16. Tongue grafting is one of the safest methods to use, but it is not always the easiest to perform. Page 470.

17. Side grafting is one of the best forms of inserting cions. It is easily performed and gives satisfactory results. The vine does not need to be severed, and the same stock can be repeatedly used. Page 471.

18. The grafting of grape cuttings, whether rooted or not, is carried on in this country to a very limited extent, but it may become an important operation in the future. Page 472.

19. The tongue graft is probably the best form to use for grafting cuttings, but other methods may be employed with success. Page 472.

20. A vine properly grafted is probably as long lived as one upon its own roots, if suitable stocks are selected. Page 473.

E. G. LODEMAN.

Bulletin 78. **November, 1894.**

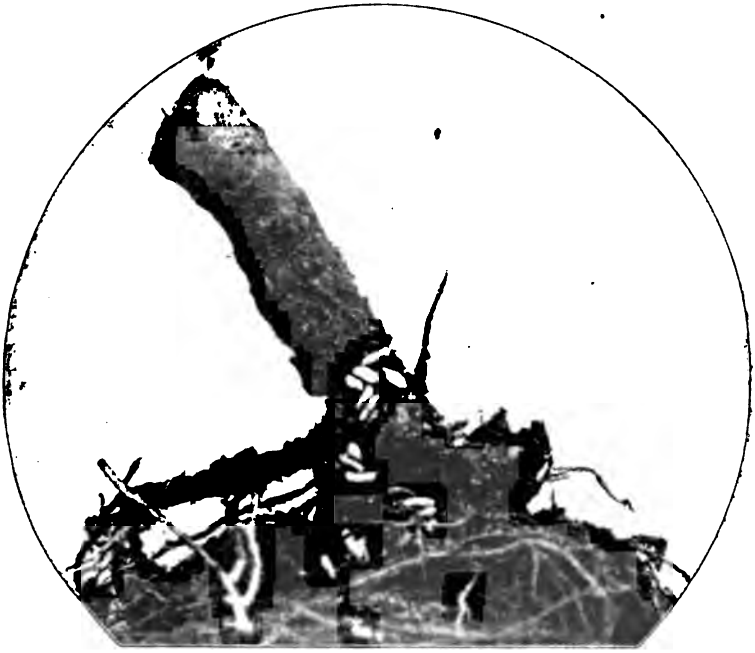
Cornell University Agricultural Experiment Station.

ENTOMOLOGICAL DIVISION.

The Cabbage Root Maggot

WITH NOTES ON

The Onion Maggot and Allied Insects.



By M. V. SLINGERLAND.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot with notes on the Onion Maggot and Allied Insects.

THE CABBAGE ROOT MAGGOT.

Phorbia brassicae Bouché.

Order DIPTERA ; family ANTHOMYIIDAE.

For many years, growers of cabbages and cauliflowers have recognized in this pest a most formidable enemy of these desirable vegetables. Peter Henderson has said that "tens of thousands of acres of cabbages and cauliflowers have been utterly ruined in a single season by this insect." And the destruction still continues, seemingly unabated.

Every year reports of the ravages of this pest have reached us from different parts of the State. But it was not until the spring of the present year that a favorable opportunity occurred to study the insect, especially with a view to finding some effective preventive or destructive method of combating it. Then, at the urgent request of several cabbage growers on Long Island, the writer began work on the pest. In March, several of the leading gardeners on the Island were visited, and all willingly offered their services, their cabbage fields, and a sure crop of "maggots" for experimentation.* Many gardeners had given up trying to grow early cabbages and cauliflowers solely on account of this pest. A very favorable field for operations was found at Mattituck, near the eastern end of the Island and in the center of one of the greatest cabbage seed growing regions in the world. In April and May, two subsequent trips were made to Mattituck for the purpose of applying preventive and destructive substances and to note their effects. On the last trip, thousands of the "maggots" were secured and brought to the insectary for further experimentation with destructive substances, and for the study of their life-history.

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*The writer is indebted to Messrs. Henry Hicks, C. L. Allen, P. H. Scudder, and J. M. Lupton for much information and many kindnesses. To Messrs. T. E. Reeve and Son, are we especially indebted for the use of their cabbage field for experiments, and for their careful services and important information while the experiments were in progress.

This six months' study of the insect has revealed many new facts regarding its habits, life-history, etc., and yet there are many questions of considerable importance still unsolved; and especially is there need of more careful experiments in combating it. However, we feel that enough has been accomplished to warrant the preparation of this bulletin. It has been made as complete as possible; all accessible records have been searched in order that this record may include what has heretofore been known of the pest and the methods recommended to combat it. In other words, the aim has been to bring together the multitudinous scattered facts recorded about this pest and combine them with the new facts revealed by our observations, thus making them all readily accessible to gardeners and others in a single publication

THE DISTRIBUTION AND PAST HISTORY OF THE PEST.

Like its food-plants, this insect is doubtless of European origin; although it was seen and named in this country only a few years after its first description appeared in Germany, over 60 years ago.

It was considered a serious pest as early as 1833; Bouché then wrote: "It often destroys whole cabbage fields." That it has continued to be a pest in Germany is shown by the fact that it is discussed by all later German writers on garden insects; and collectors have recently reported it common in that country. In 1835, it was found in France, but seems never to have attracted much attention as a pest there. It has been recognized as a pest in England since 1840; possibly it was known there by Major (Treatise on Insects) in 1829 as the cauliflower fly. There are many discussions of the pest in later English publications. Nearly every year during the past decade the pest has been reported by Miss Ormerod as doing much injury in various parts of England. In 1872, it is recorded as doing considerable damage to radishes in the Netherlands. Thus it seems to have been recognized as a serious pest since the early part of the present century in various parts of Europe, especially in Germany and in England.

It was first recorded in the United States by Dr. Harris who gave it a name in 1835, and described it in 1841 from Massachusetts. Dr. Fitch, in 1867, said it was so destructive in our State in 1856 and 1857 that in many neighborhoods it was impossible to obtain plants for setting out. In 1857, the pest was being fought in Maryland. Prof. Prentiss found the "maggots" doing much damage in Michigan in 1867. Trimble records it destructive to his radishes in New Jersey in 1870. In 1875, Dr. Packard said he had known the pest in Maine for over twenty years. A gentleman in Pennsylvania had nearly four acres of cabbages destroyed in 1877; and the next year the pest was very destructive in Luzerne County, in the same State. In 1885, Fletcher reported that the pest had that year destroyed from 25 to 75 per cent. of the cauliflowers in Canada; it occurred in all of the Provinces from Nova Scotia to Vancouver's Island (it must have been present in Canada for many years previous to have attained this wide range). A radish grower reported the pest from Colorado in 1886; Cockerell recorded it from the same State in 1889. In 1887, turnips suffered from the "maggots" in Vermont; in the same year the insect was also reported from South Carolina and Georgia. In 1889, experiments were tried against the pest in Alabama and in the State of Washington. It was injurious in Mississippi and Wisconsin in 1892. The following year, 1893, Alwood reported it very destructive in Virginia. This year it has been recorded as injurious in Oregon.

Thus the pest was introduced into this country from Europe early in the present century, perhaps first appearing in Massachusetts, from whence it gradually spread north, west, and south into the neighboring States. In about 25 years it had reached Maine on the north, Maryland on the south, and Michigan on the west. In 20 years more it had reached the Pacific Ocean, entered Colorado, and passed through South Carolina into Alabama. In a little more than half a century it had thus spread over the greater portion of the United States and Canada. Doubtless it is now present in injurious numbers in every State where its food-plants are grown to any extent.

Whenever the pest obtains a foot-hold, it usually appears in alarming numbers year after year if its food-plants continue to be grown in the neighborhood. In England it has been very destructive almost every year since 1880. In the United States, the gardeners in this State (especially in the neighborhood of New York City, over the line in New Jersey and throughout Long Island) and in Michigan have suffered severely from the pest almost every year, as the records show, for the past 25 years. Many market gardeners on Long Island have abandoned the growing of early cabbages, cauliflowers, and radishes on account of this formidable pest. In 1887, Peter Henderson said: "tens of thousands of acres the past season have been, of both cauliflower and cabbage, utterly ruined by maggots." In Canada the pest has been especially injurious in 1885, 1887, 1890, 1892, and 1893; in 1892 it was considered the most destructive insect of the year.

From this somewhat detailed account of the past history and distribution of the Cabbage Root Maggot, we may draw this general conclusion: that it is common and often does much damage throughout Europe, from whence it was introduced early in the present century into the United States and Canada where it now occurs in nearly every State and Province in sufficient numbers to annually destroy thousands of acres of Cabbages, Cauliflowers, Radishes, and Turnips, thus causing a loss of thousands of dollars every year to the gardeners of America.

ITS FOOD-PLANTS.

The name Cabbage Root Maggot, by which this pest is most commonly known, would indicate that its food-plant was the cabbage, *Brassica oleracea;* this species now embraces the kales or borecoles, collards, brussel's sprouts, cauliflower, and broccoli. However, we find that the insect has quite a range of food-plants, but apparently confines itself chiefly to the *Cruciferae* or Mustard Family.

When it was described in 1833, it was said to live in the roots and stems of the different kinds of cabbages; the next year the same author described it, under another name, as living in radishes, *Raphanus sativus.* More recently Taschenberg and Schmidt-Göbel have added the following food-plants of the insect in Germany: *Raphanus radiola*, turnips, and stocks (*Matthiola*). In England, the pest has been recorded, not always under the same name, however, on cabbage, including the other forms of this species, on turnips (*B. rapa*), and on swede turnips (*B. campestris*). Miss Ormerod says that Mr. Meade reared the insect in 1882 "from maggots found in earth round partly-decayed Clover roots."* The same author believes that the maggots feed on the stable manure used on cabbage fields. However, no definite observations are given in support of this opinion. In 1833, Bouché said: "Avoiding the use of new dung is likewise of no avail as these root-devouring larvae are not annoyed by the want of it; nor are they conveyed in it into the field, as some believe." There is but little doubt that where large quantities of stable manure are used the pest sometimes appears in the greatest numbers. Possibly the smell of the manure may attract the insect, and certainly the stable manure would lighten up heavy soils, thus enabling the maggots to work to a better advantage and do more damage; these seem the more probable explanations of the presence of the pest in increased numbers where stable manure is used, and not because the manure furnishes a further supply of food for the maggots.

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*I find no reference to this in Mr. Meade's writings. Perhaps some roots of a Cruciferous weed were overlooked among the Clover roots; these, as will be shown later, would account for the presence of the insect. This is an important point in the habits of this pest and should be further investigated.

In this country the insect first attracted attention as a radish pest nearly 60 years ago; Dr. Harris then thought it different from its European congeners and named it as a new species*. In 1867, Dr. Fitch recorded the insect as infecting cabbages, cauliflowers, turnips, rutabagas, and radishes. Although he discussed the Cabbage-fly and the Radish-fly under different names, yet he was unable to discover any differences between them.

In 1872, Mr. Brill, a market gardener, recorded that he "believed the Cabbage Maggot and Radish Maggot to be one and the same." Five years later, Dr. Riley said: "The species affecting the Cabbage, the Onion, the Radish, etc., have received different names but several of them doubtless constitute but one species."

During the next decade, all writers seem to have considered the Cabbage-maggot and Radish-maggots as separate insects. In 1887, however, Prof. Cook gave a detailed account of some very important experiments to prove his belief that the insects which attack the onion, the cabbage, and the radish are but trimorphic forms of one species. His experiments quite conclusively show the identity of the cabbage and radish maggots; but the evidence is not sufficient to support the conclusion that the Onion and Cabbage-maggots are the same.†

The next year Prof. Cook said: "I am more and more convinced that the insects of the genus Anthomyia, working on onions, cabbages, and radishes are one and the same species. This year beans have been seriously injured again by a similar, I believe the same species." However, this Bean Root Maggot appeared in Canada in 1885, and Mr. Jack (17th Rept. Ont. Ent. Soc., p. 17) shows that it is the Fringed Anthomyiian (*Phorbia fuscaceps* Zett.), and not the Cabbage Root Maggot.

Recently, Mr. Fletcher sent me considerable material reared in Canada from Cabbages and Turnips (British Columbia). Only one species, the Cabbage Root Maggot, was represented.

In 1882, Dr. Lintner recorded this pest in a new role, not suspecting, however, that it was the common Cabbage Root Maggot. He bred the insect from maggots which were mining in the leaves of beets. This is the only well-authenticated instance of the pest attacking other than Cruciferous plants. This leaf-mining habit of the insect seems not so improbable, however, when it is known that in 1878, Dr. Riley found the maggots burrowing in the stout mid-ribs of cabbage leaves in the summer; and Mr. Fletcher has recorded, in 1891, the pest as mining in the mid-ribs and boring through the heads of winter cabbages in storehouses.

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*In the notes on the bibliography in the latter part of this bulletin, I have given my reasons, from the systematist's standpoint, for considering Dr. Harris' Radish-maggot the same as the Cabbage Root Maggot.

†Through the kindness of Prof. Davis, I have been able to examine some of the material bred by Prof. Cook in 1887. I saw specimens of flies bred from radishes, and flies and maggots reared on cabbages; all were typical *Phorbia brassicæ*, Bouché, the Cabbage Root Maggot, while the flies and maggots bred from onions were all typical *Phorbia ceparum*, the Onion Maggot. There is another Anthomyiian which has been bred from onions, namely, the Fringed Anthomyiian, *Phorbia fuscaceps* Zett., that quite possibly may have been present with the Onion and the Cabbage Root Maggots in Prof. Cook's experiment. Dr. Riley has bred this species from cabbages and radishes, and to a casual observer it would form a good connecting link between the large indistinctly marked Onion Fly and the Cabbage Fly. I have not seen specimens of Prof. Cook's Raspberry Maggot, but Mr. Fletcher sent me one wing and a puparium of an Anthomyiian which he bred from raspberry canes; the wing was similar to that of the Cabbage Fly, but the puparium was distinctly different from that of any Anthomyiian with which I am acquainted. Thus it is very doubtful if the raspberry should be recorded among the food-plants of the Cabbage Root Maggot.

Breeding experiments here at the insectary have developed further confirmatory evidence in support of some of the conclusions to be drawn from the above account of the recorded food-plants of this pest. And these experiments have also revealed several new food-plants of the insect, which will throw new light on its habits and life-history; and which are of considerable importance in connection with the methods to be used in combating the pest.

In 1891, maggots ruined a field of turnips at Ithaca; the insect was bred at the time, and it proves to be the Cabbage Root Maggot. This year several turnips and radishes were growing in an exposed bed in the insectary; and some of them were found to be attacked by maggots which produced the Cabbage-fly. The pest has also been bred, in the insectary, from the buried stems of seed cabbage.

Thus these breeding experiments, the evidence of other observers, especially of Dr. Fitch and Prof. Cook recorded above, and the identity of all the Cabbage and the Radish-maggots examined from various parts of the country seem, to the writer, sufficient proof that *the* Cabbage and *the* Radish Maggot are the same insect.*

After learning that it is the universal testimony of cabbage and radish growers that the maggots do but little damage to late crops of these vegetables, the question at once occurred to us, has the pest other, as yet unsuspected, wild food-plants? Naturally our attention was turned to the Mustard-like weeds which are usually to be found in abundance in every garden or cultivated field and along the road-sides. Therefore, in the latter part of May, plants of the well-known Shepherd's Purse (*Capsella bursa-pastoris*), and of the Common Winter Cress or Yellow Rocket (*Barbarea vulgaris*) were transplanted from the field to cages in the insectary; and 100 maggots, brought from Long Island, were put about the base of each plant. Three weeks later the cages were examined. The maggots had eaten freely of the roots of the *Barbarea;* but the roots of the Shepherd's Purse showed only slight indications of having been eaten, and many of the maggots had failed to develop.

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* I say "*the* Cabbage and *the* Radish Maggot" because two other Anthomyiians, *A. radicum* the Root Maggot, and *P. fuscipeps*, the Fringed Anthomyiian, are recorded as feeding on these vegetables; but I believe the latter rarely does, and the former not nearly so commonly as does *P. brassicæ*.

This experiment suggested an examination of plants in the field. About June 15, many plants of the Shepherd's Purse, the Common Winter Cress, and Hedge Mustard (*Sisymbrium officinale*) were examined in various localities near the insectary. The result was surprising. Scarcely a plant of the last two weeds had not had their roots considerably damaged by maggots; but not a plant of the Shepherd's Purse seemed to have been attacked by them. That these maggots found at the roots of these weeds were the Cabbage Root Maggot was shown by breeding the insect in cages on the weeds, and also by transferring maggots from the weeds to cabbage plants and producing the typical Cabbage-fly in both cases.*

These experiments thus show that the Cabbage Root Maggot has several wild food-plants to which it can and probably does resort in case none of its, perhaps preferable, cultivated food-plants are grown in the locality. Doubtless the pest also breeds upon the roots of several other common species of the Mustard-like weeds, some of which may be more common in certain localities than either of the two upon which we have found the maggots common about Ithaca. Probably the natural food-plants of this pest are some of the Mustard-like weeds, many of which have been introduced here from Europe; and one may thus expect to find the Cabbage Root Maggot wherever these weeds occur.

It is remarkable that no one seems to have discovered these maggots on these weeds, nor have suspected that the Cabbage Root Maggot might breed upon such plants. That they do thus feed upon weeds is in itself an important fact, but we believe it will serve to explain other more important points in the life history of the pest which have heretofore puzzled observers.

To briefly summarize this detailed account of the food-plants of this pest, we may say that it has been recorded in Europe on the cabbage (including the cauliflower, borecoles, etc.), the radish (*Raphanus sativus* and *radiola*), the turnip (*Brassica rapa*), the ruta baga and swedes (*Brassica campestris*), and on stocks (*Matthiola*); the reported feeding on clover roots and manure needs further confirmation. In this country the Cabbage Root Maggot feeds upon most of the above plants and on at least two common Mustard-like weeds, the Common Winter Cress (*Barbarea vulgaris*), and the Hedge Mustard (*Sisymbrium officinale*); the maggots infesting onions, beans, and raspberry canes are different insects, distinct from each other and from the Cabbage Root Maggot.

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* One of the Fringed Anthomyiians (*Phorbia fusciceps*) was bred from a maggot found on the roots of the Hedge Mustard (*S. officinale*).

INDICATIONS OF THE PRESENCE OF THE PEST.

Some gardeners who are familiar with the different stages of the insect, can often tell, by watching their plants closely about May 1, whether the pest is laying eggs or not, and thus do not have to wait until its presence is indicated through its effect on the plant. It is one of the chief aims of this bulletin to thus render the different stages of this insect familiar, by means of descriptions and illustrations, so that all observing gardeners can recognize its presence in their cabbage fields and radish beds, before the maggots fairly begin their ruinous work. Unfortunately, however, many gardeners recognize the insect only in its maggot stage. But as the pest is then out of sight in the soil, its presence is often not suspected until much damage has been done. Sometimes the pest gets at work early enough in the spring to catch the tender plants in exposed seed beds. Here the small plants quickly succumb to the attacks of the maggots; for a few days the infested plants may have a weak, sickly appearance, when suddenly, in a day's time, they will wilt down and die. Sometimes the seed beds of late varieties suffer in the same way in June or July. Young radish or turnip plants succumb in a similar manner.

Usually, however, the maggots first make their presence felt on the plants after they have been set in the field about two or three weeks. This year, on Long Island, the plants began to show the effects of the maggot about May 15; the time will vary with the season, locality, and latitude.

If cabbage plants once get thoroughly established before the maggots attack them, unless the maggots occur in considerable numbers, the plant may show scarcely any indications of the presence of the pest. This is due to the fact that the plants of the cabbage tribe are all gross feeders; and thus always require a very rich soil from which they quickly repair injuries to their root-system, especially if the soil is kept moist by rains or otherwise. Gardeners understand this and often hill up their plants, which then soon send out new roots farther up on the buried stem.* This power of the plant to overcome the ravages of a few maggots is an important point, especially in connection with some of the remedies recommended for the pest. In radishes and turnips, however, a single maggot may render the root unfit for food without otherwise materially injuring the plant; quite a number of maggots might attain their growth in the large fleshy root of these plants without indicating their presence by any very noticeable change in the visible portion of the plant. Thus in the case of these crops, unless the maggots occur in large numbers, the presence of the pest may not be discovered in a well-established root until it is pulled up.

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* Mr. Reeve of Mattituck said he had often saved many of his cabbage plants, after they had been nearly ruined by the maggots, by carefully hilling up around the stems and watering them well. New roots would soon be put out, and he had produced many good, but later, heads of cabbage in this way.

Therefore, how soon the plant will soon show the presence of the pest will depend upon its size, the number of maggots at work, the amount of quickly available fertility in the soil with which to repair damages, and the conditions of the weather, as amount of rainfall, etc.

Usually the first indications of the presence of the pest on plants of the cabbage tribe is a noticeable checking of their growth, and a tendency of the leaves to wilt badly under a hot sun. The leaves soon take on a sickly bluish color, a few days later the whole plant wilts, often topples over, and soon dies. If one of these plants be pulled up, the stem and roots often present the appearance shown in the illustration on the front of this bulletin and in figure 1, both of which are from photographs of specimens pulled up in a Long Island garden. It is not an unusual thing for a gardener to suddenly find on some hot day a majority of his plants of cabbages or cauliflowers thus wilted and toppled over where the maggots have been very numerous. It is a sad plight when one realizes how much money and labor has been spent to bring the plants to that stage; and what is still worse, they are then often beyond help even if the maggots were killed at once. So that gardeners should familiarize themselves with the other stages of the insect and when to look for it, thus making it unnecessary to wait until the destructive period is reached before being able to tell whether the pest is present or not, so as to check it if necessary before the crop is ruined.

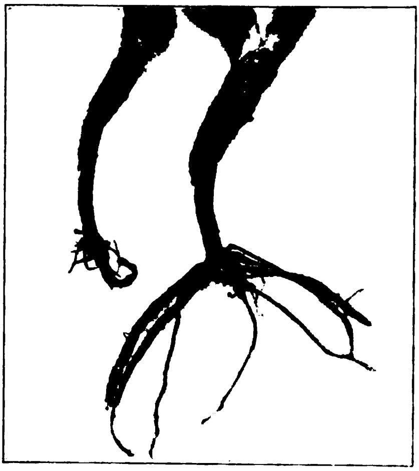

FIG. 1.—*Stems and roots of cabbage plants that had succumbed to the attacks of the maggot; one-half natural size.*

In brief, the presence of the pest, where it occurs in considerable numbers, is indicated by a checking of the growth of the plant, a tendency to wilt badly under a hot sun, and a sickly bluish cast to the foliage.

THE INSECT'S APPEARANCE.

The larva or maggot.—Everyone who has had any experience with this pest is familiar with it in this—the maggot or larval stage. And yet, we have not been able to find an illustration by which the maggot could be definitely recognized. The only observers who have given us definite descriptions of this form of the pest are Bouché (who gave the insect its name in 1833), and Dr. Fitch (in 1867); all other descriptions are either inadequate or evidently compiled from these authors.

The maggots, from their birth, are similar in form to the full grown one represented in figure 2, and are always footless and of a shining white color, sometimes tinged with yellowish. The body is cylindrical, tapering to the cephalic end where the two strong, black, parallel, curved, rasping jaws project downward; these hooks are connected with an internal blackish framework which is indistinctly visible through the skin of the maggot (Fig. 9). The caudal end of the body ends bluntly, appearing as though cut off obliquely downward and backward.

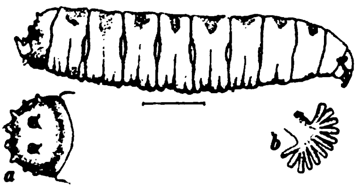

FIG. 1.—*The Cabbage Root Maggot, side view, enlarged; the hair line beneath represents the natural size.* a, *dorsal view of caudal segment, showing size, number and arrangement of fleshy tubercles, much enlarged;* b, *outline of a cephalic spiracle, greatly enlarged.*

A full grown maggot measures .32 of an inch (8 mm.) in length. On each side of the body just back of the head is a minute, light brown, fan-like projection, or spiracle (shown greatly enlarged at *b* in figure 2) which leads into the trachea or breathing organs of the maggot.* These trachea extend the length of the body in two main trunks which throw out many ramifying branches, and again open to the surface near the center of the flat oblique caudal end of the maggot in two raised, roughened, darker brown or blackish spiracles shown near the center of figure 2, *a*. Around the margin of this flattened caudal end of the maggot there are 12 fleshy pointed tubercles; the two lower ones are larger, of a brownish color, and always bifid or two-

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*Bouché describes these cephalic spiracles as having 7 to 9 divisions. This seems to be true of the young larvæ (those about one-half grown), but in full grown specimens we find the number to be usually 12. The number varies slightly and thus may not prove of much specific value.

toothed,* thus making 14 fleshy points in all (Fig. 2, *a*). The tubercle on the margin just above these bifid ones is equally as long but narrower. The other tubercles are comparatively small, and the four lateral ones, two on each side, are a little below the margin. On the venter, a little cephalad of the bifid tubercles and just caudad of the vent, are two more fleshy pointed tubercles projecting caudo-ventrad. The number, size, and arrangement of these tubercles about the caudal end of the maggot (Fig. 2, *a*) have been given in detail, for our observations lead us to believe that they, especially the four larger more ventral ones, offer specific characters by which the Cabbage Maggot may be easily recognized and separated from the other common Anthomyiian maggots.

In short, the full grown cabbage maggot is about .32 of an inch (8 mm.) in length, white, cylindrical, tapering cephalad and obliquely truncate caudad with 12 fleshy tubercles around the caudal margin, the lower two of which are two-toothed; and the cephalic spiracles have 12 divisions.

The puparium.—This is the name applied to the case within which the maggot passes through a wonderful transformation which results in the perfect insect. This puparium is really the skin of the maggot which has hardened and separated from the creature within, which is then called the pupa; thus the maggot uses its own skin as a home to protect it while it changes to a tender pupa and thence to the perfect insect.

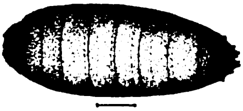

FIG. 3.—*The puparium, dorsal view, much enlarged.*

Many gardeners have doubtless seen these puparia, but did not realize that they were an important stage in the life of this pest. They can easily be found in the soil about badly infested plants in June. As shown in figure 3, the puparium is elliptical ovate in form, and being simply the dried skin of the maggot, it naturally shows the same fleshy tubercles at the caudal end, usually less distinctly but sufficiently distinct for the specific determination of the insect. It varies from a light to a dark brown in color, depending on its age, whether a few hours or several days old. It is shorter than the maggot, measuring only about .2 of an inch (5 mm.) in length; there is considerable variation in size, some being fully one-third smaller than others.

*** Dr. Fitch says this is not true of the smaller young larvæ. I have not examined specimens less than one-half grown, but it holds true for all I have seen.**

As the whole future destiny of the insect is enclosed in these puparia, gardeners should be able to recognize the pest in this stage so that they may destroy them at every opportunity, thus "nipping in the bud" a future destructive crop of maggots.

The adult insect.—After a certain period of incubation in the puparia just described, this pest appears as a creature totally different from the familiar maggot. It is the adult insect, which is known as the fly of the Cabbage Root Maggot by the few gardeners who are familiar with the pest in this stage. Both sexes of the fly are shown greatly enlarged (the hair line beneath each indicates their natural length) on plate I; the right legs and wing were removed before photographing so that the details on the other legs and wing might not be obscured. By the casual observer the adult insect might easily be mistaken for the common house fly. It resembles the house fly in general appearance, but, although it varies somewhat in size, it is considerably smaller. Like the house fly, it has only two wings, but in the cabbage fly these extend farther back beyond the end of the body and are shut farther over each other on the back of the fly. The body of the fly is about .2 of an inch (5 mm.) in length, and the sexes differ considerably; some of these differences are well shown in the figures on plate I, as will appear from the descriptions of each sex which follow.

The male fly is of a general dark ash-grey color with three rather broad blackish dorsal stripes on the thorax, and a wide, black, dorsal stripe extending along the abdomen becoming narrower toward its extremity and more or less dilated opposite the upper margin of each segment which is marked with a narrower transverse black stripe. Many bristly hairs project from different parts of the body, and the abdomen is sub-cylindrical, narrow, and but slightly tapering. The eyes, occupying a greater portion of the head, nearly touch each other above. The legs are black and strongly bristled; on the under side of each hind femur near its base is a tuft of these bristles which are characteristic of this Cabbage-fly. This tuft is quite noticeable on the femur of the male fly in figure 4, especially when comparison is made with the corresponding femur of the female shown in figure 5; by this character alone, the male insect can be recognized and separated from the other common Anthomyiian pests. There is also a characteristic row of short bristles, unequal in size, on the inner side of the hind tibia of the male insect that will help to distinguish the species.

The female fly, figure 5, plate I, is of a lighter ash-grey color, quite indistinctly striped on the thorax and abdomen, and not so strongly bristled as

PLATE I.

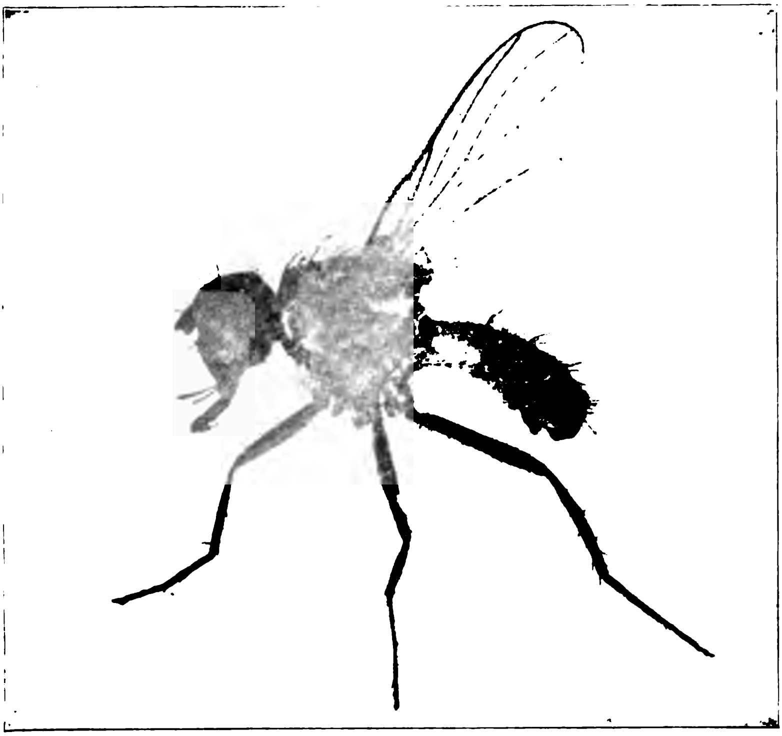

FIG. 4.—*The male fly, side view with right legs and wing removed, greatly enlarged; natural length of the body represented by the white hair line below.*

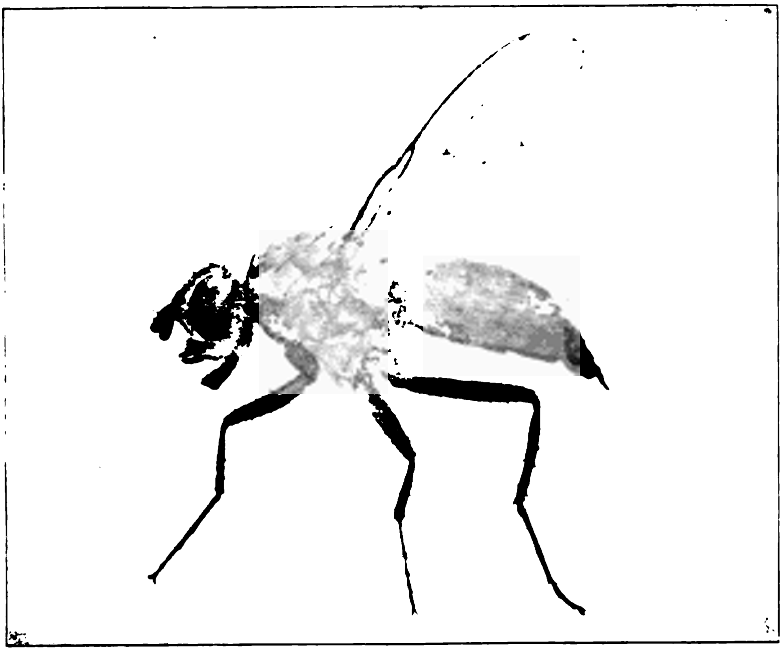

FIG. 5.—*Female fly, similar view and magnification as the male fly in figure 4 above.*

the male. Her eyes are also quite widely separated above. The abdomen is of a more elongate ovate shape with a pointed apex. There seems to be no special characteristic by which the female fly can be recognized and separated from some of the other common Anthomyiians; it is necessary that it be found associated with its male to determine it with certainty.

Gardeners who are not now familiar with these flies can soon become so with the aid of the above descriptions and illustrations, supplemented with a knowledge of their habits and times of appearance which are discussed farther on under the life history of the pest.

ITS CLASSIFICATION.

This cabbage pest is a member of that peculiar order of insects —the true flies—known as the *Diptera*, none of whose members have more than two wings. The well-known House Fly, the Mosquitoes, the Hessian Fly, the Crane-flies, the Bot Flies, and many other familiar insects are typical members of this order. The pest under discussion belongs to the family *Anthomyiidae* whose members are commonly known as the Anthomyiians, which in the original Greek means "flower flies," from their habit of frequenting various flowers. There are more than a hundred other members of this family in this country, and among them some well known pests like the Onion Maggot, and others. The Cabbage Root Maggot is probably the most common and best known member of the family.

Its scientific name.—Naturalists are not agreed as to the name by which this insect should be known. After a critical survey of all the evidence known to us, we are convinced that the pest should be called *Phorbia brassicae.**

Other names have been applied to the insect as is shown in the synonomy of the pest on another page, but we believe the weight of evidence at present is decidedly in favor of *brassicae*, the name given by Bouché in 1833. This specific name of the pest comes from the generic name *Brassica*, of the plants on which the insect usually feeds. Until within a few years, the insect has usually been referred to the genus *Anthomyia*, sometimes to *Chortophila*; but the latest authority places it in the genus *Phorbia*, hence its complete name is *Phorbia brassicae.*

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*For a detailed account of our reasons for adopting this name, see the discussion which follows the bibliography of this insect on the last pages of this bulletin.

Its popular name.—From the time the insect first became known by a scientific name, it has been popularly known as the Cabbage-fly or maggot, and equally as commonly known as the Radish-fly or maggot; some have more correctly called them Cabbage or Radish Root Maggots. It has also been called the Cauliflower and the Turnip-maggot when these were the crops under discussion. No one has doubted that the common Cabbage, Cauliflower, and Turnip-maggot were the same insect, and we now believe the Radish-maggot is also the same.*

Therefore, its scientific name, *brassicae*, at once suggests the cabbage, and the insect is more familiar to gardeners as the maggot infesting the several varieties of cabbage than as the radish-maggot; for these reasons we use the popular name of Cabbage-fly, or better and more familiar to gardeners, the Cabbage Root Maggot.

COMPARISON OF THE PEST WITH OTHER COMMON ROOT MAGGOTS OR ANTHOMYIIANS.

Our study of this pest has been greatly complicated by the lack of definite comparative knowledge of it and some other common Anthomyiians which have been confounded with it. This lack of comparative knowledge has given us a somewhat complicated synonomy for the insect, and has led some observers to confound two or three different insects.

We have found that there are three common Anthomyiians more or less intimately associated with the Cabbage Root Maggot, two of which doubtless attack the same plants. To save future observers the labor it has cost us to understand these closely allied and easily confused root maggots, it seems advisable to include in this bulletin the following brief discussion of each of these allied forms.

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*A detailed discussion of our reasons for believing the common Cabbage and Radish-maggots to be identical is given on a previous page under the food-plants of the pest, and also from the systematist's standpoint in the discussion of the synonomy near the end of the bulletin.

THE ONION MAGGOT.

Phorbia ceparum, Meigen.

This Anthomyiian has been recognized as a formidable pest by onion growers, both in Europe and America, since the beginning of the present century. It is probably as widely distributed, and as destructive wherever it occurs, as is the Cabbage Root Maggot.

The insect is *par excellence* the Onion Maggot, for it seems never to have been recorded on any other food-plant. Its presence in an onion bed is indicated by the leaves becoming soft and flaccid to the touch, often changing to a yellowish color, and finally wilting.

The maggot closely resembles the Cabbage Root Maggot (Fig. 2) in size, shape and color.

The caudal segment, however, is quite different in the arrangement and number of its fleshy tubercles; figure 6, *d* and *e*, represents the caudal segment of the Onion Maggot as seen from the side and from above. There seems to be no difference in the size, number, and arrangement of the dorsal and lateral marginal tubercles in our common root-feeding Anthomyiians; there seems to be always eight small ones. There is often a decided difference in the two ventral marginal tubercles, however, as a comparison of *e*, figure 6, and *a*, figure 2, will show. In the Cabbage Root Maggot these two are always bifid, while in the Onion Maggot they are single pointed. The latter also has, in addition to the two tubercles just caudad of the vent, two smaller ones on the venter just cephalad of the two large ventral marginal tubercles; the tips of these small tubercles appear between the larger ones when the caudal segment is viewed from above as shown at *e* in figure 6. The number of divisions of the cephalic spiracle is usually ten, but sometimes eleven or twelve.* Thus the Onion Maggot is easily distinguishable from the Cabbage Root Maggot.

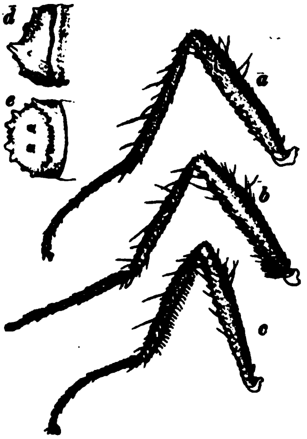

FIG. 6.—*a, b, c, right hind leg of the male of the Onion Fly, the Cabbage Fly, and the Fringed Anthomyian, respectively. d, side view of caudal segment of the Onion Maggot; e, dorsal view of the same. All are much enlarged.*

The adult insect, the Onion Fly, closely resembles, but is slightly larger than the Cabbage Fly. Both sexes of the Onion Fly are of a light grey color, with the thorax of the male marked with four indistinct brownish

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*I have not been able to compare fresh specimens of the Onion Maggot; with such specimens, I presume other distinctive characters would appear.

stripes and a sub-continuous stripe of rather indistinct narrow triangular black spots down the dorsum of the abdomen. A glance at the hind femur of the male Onion Fly will readily distinguish it from the one infesting cabbage. At *a* in figure 6 is shown the right hind leg of the male Onion Fly greatly enlarged, and at *b*, the same leg of the Cabbage Fly; the tuft of hairs at the base of the femur in *b* is a striking contrast to the comparatively bare base of the femur of *a*, the Onion Fly. The female flies of these two species are not easily separable unless found associated with their males.

As the name of this onion pest indicates, it is closely allied to the Cabbage Root Maggot; they belong to the same genus, *Phorbia*. Its specific name *ceparum* comes from the specific name of its food-plant, the onion (*Allium cepa*).

The life-history of the Onion Maggot, so far as recorded, shows that it is very similar to that of the Cabbage Root Maggot. Thus our discussion of this phase of the latter insect will be of equal interest, in many respects, to onion growers. From the nature of the difference in the vegetables attacked, the Onion Maggot probably differs somewhat in its habits, but many of the statements we make regarding the life-history of the Cabbage Root Maggot will also apply to the Onion Maggot.

Some, and doubtless all, of the natural enemies which we record as attacking the Cabbage Root Maggot, also prey upon the Onion Maggot.

Our detailed discussion of the methods of preventing the ravages of the Cabbage Root Maggot, especially when it attacks radishes, will be found equally applicable to this most formidable pest of the onion grower.

Therefore, onion growers should understand that although this bulletin primarily treats of the Cabbage Root Maggot, much that it contains applies equally well to their worst pest, the Onion Maggot; especially is this true as regards the discussion of the life-history and methods of combating the former pest.

THE ROOT MAGGOT.

Anthomyia radicum, Linn.

Although this insect has been known for more than a century (it was described by Linnaeus in 1761), our knowledge of its habits and life-history is very indefinite and meagre. The writer has never seen the insect in any stage, so cannot hope to add anything new to what has already been recorded. But this Root Maggot has often been confounded with the Cabbage Root Maggot, as our synonomy of the latter insect shows. And as this confusion of these species has cost us no little trouble, we desire to here record what we have been able to learn about it from very scattered sources, with the hope that it may help to clear the way for others; and especially that it may induce some observer, opportunely situated, to give us more definite knowlege regarding this Root Maggot.

It is an European species, and has been discussed by several German and English writers. However, there seems to be no record of any extensive damage to crops directly and definitely traceable to it. True, Curtis discussed it as a turnip pest in England in 1843, but we now know that his turnip maggot was not the Root Maggot, but undoubtedly the Cabbage Root Maggot.*

The only reason for believing that this Root Maggot occurs in this country is the fact that in 1878 one of the flies was found by Mr. Meade in a collection of flies sent him from the Cambridge Museum in Massachusetts. No other specimens are at present known to exist in this country, and no injury has as yet been traceable to the species here.

All accounts of the maggot of this insect are compilations of Bouché's description (in 1834) of a maggot which he said occurred by the thousands in human dung. He describes a maggot very different from the Cabbage Root Maggot; his Dung Maggot is said to be muricated with black all over, even the fleshy tubercles on the caudal segment, and other differences appear in his description. If Bouché's description of this Root Maggot is correct, and no one has yet questioned his determination of the species, it ought to be easily distinguished from the other more common cabbage and onion maggots.

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* Mr. Meade writes me that Curtis' illustration of the adult of his turnip maggot (which he called *Anthomyia radicum* Linn.) is a good figure of the cabbage fly. This figure has appeared many times in European and American literature as that of *radicum*. Curtis' account of these Anthomyians in his "Farm Insects" has been the mine from which many writers on the subject have drawn their information, yet Dr. Fitch seems to have been the only one who has heretofore doubted Curtis' determinations of the species. One or two other inaccuracies which crept into Curtis' account are pointed out for the first time later on in this bulletin; they have been handed down through the literature and now appear in several of the best discussions of the Cabbage Root Maggot in our American literature.

The adult insect closely resembles the cabbage fly, and is recorded as occurring frequently in Germany and as excessively common in England.

Mr. Meade says it may be recognized by its projecting face; by the scales of the base of the wings being unequal in size; by the thorax being black and marked in the male by two short, grey, narrow stripes; by the rather short, wide, somewhat pointed abdomen, with a longitudinal dorsal black mark, crossed by three transverse straight black stripes extending of an equal width to the margins; and by the third and fourth longitudinal veins of the wings being slightly convergent at their extremities. This inequality in the size of the alular scales, the shape of the abdomen, the markings on the body, and the convergence of the third and fourth longitudinal veins of the wings are characters, any one of which would distinguish the male fly, at least, from the cabbage fly; a reference to our descriptions and figures of the cabbage fly will enable one to more clearly understand some of these differences.

In fact, the flies of the Cabbage Root Maggot and the Root Maggot differ so much that they are now placed in different genera. The Root Maggot belongs to the genus *Anthomyia*. Its specific name, *radicum*, indicates that it lives on the roots of plants.

However, as we have mentioned above, Bouché recorded the maggots as breeding in human dung. Other authors say it feeds on the roots of the cabbage tribe and on radishes. It would seem as though there must be some mistake here, for Bouché states that it needs only 8 to 10 days for its growth from the egg to the pupa. The pupa stage he says lasts 2 or 3 weeks. Nothing is said about it feeding on roots. It seems hardly probable that a maggot working in a living root would develop so quickly. This point should be investigated. If Bouché has made a mistake, it should be known, and the true Root Maggot definitely described.

One can readily see from this brief discussion of the Root Maggot, how incomplete and indefinite our knowledge is regarding its habits and early stages. It is to be hoped that some observer may be able to fill this gap in our knowledge.

THE FRINGED ANTHOMYIIAN.

Phorbia fusciceps Zett.*

Our attention was first called to this insect by its appearing in June in some of our cages in which seed cabbages were growing; later, in August, flies of the Cabbage Root Maggot appeared in the same cages. This indicated that both species fed on the cabbage, and led us to carefully examine all our material to determine if the former was also associated with the Cabbage Root Maggot in its work of destruction on early cabbage. Thus we were led to study the insect somewhat closely so as to be able to distinguish it from the other common Anthomyiians in case it should appear in connection with them. A study of the literature of the species showed that it was more intimately connected with the cabbage and onion Anthomyiians and was more common in this country than we had suspected. For these reasons it seems advisable to discuss the insect briefly in this bulletin so that future observers need not confound it with the other Anthomyiians with similar habits.

The insect is probably of European origin as it received its name in Germany in 1845. Eleven years later, Dr. Fitch found it in New York State and described it as a new species. It was again described as new in France in 1866. It has also been found in England. In 1869, Dr. Riley met with it in a new role and, supposing it to be a new species, gave it another name. Eight years later, while investigating the ravages of the Rocky Mountain Locust in the west, Dr. Riley again found the same insect but under such different conditions that he did not recognize it and again characterized it as new to science. In 1885, it was found in Canada; and this year in Ohio. The insect is thus widely distributed in Europe and in this country.

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*The synonomy of this species as recently worked out from an examination of types by Rondani, Meade, Stein, and Coquillett is as follows:

Aricia fusciceps Zetterstedt. 1845.

Hylemyia deceptiva Fitch. (The Deceiving Wheat Fly.) 1856.

Chortophila cilicrura Rondani. 1866.

Anthomyia zeae Riley. (The Seed-corn Maggot.) 1869.

Anthomyia radicum var. *calopteni* Riley. (The Locust-egg Anthomyiian.) 1877.

From the following brief record of the curious habits of this Anthomyiian, one may easily understand why an observer, finding the insect living in a certain manner in one locality, would not suspect that it could be the same one that he found in another locality feeding upon an object so different as to belong to a different kingdom in nature. Dr. Fitch named the insect "The Deceiving Wheat Fly," as he found the fly very numerous hovering over and alighting upon the heads of wheat at the time they are in flower; it was erroneously regarded by some as the fly which produced the yellow maggot of the Wheat Midge (*Diplosis tritici*). Nothing further has been recorded of this wheat fly, and it had always been considered a distinct species until Mr. Coquillett recently (Insect Life, vi, 372) discovered by an examination of one of Dr. Fitch's types that it was identical with the species under discussion. The insect is next mentioned in our economic literature as a maggot working in sprouting seed corn in New Jersey, and was named the "Seed-corn Maggot (*Anthomyia zeae*)" by Dr. Riley. This insect seems not to have again been reported injuring corn in this manner.[*] A few years later, the insect appeared in a decidedly beneficial role. In the autumn of 1876 it is estimated that its maggots destroyed about ten per cent of the locust eggs in Missouri, Kansas, and Nebraska, and also sucked thousands of these eggs in the States of Minnesota, Iowa, Colorado, and Texas. Dr. Riley named it the "Anthomyia Egg Parasite," and considered it a variety of the Root Maggot (*A. radicum*). In the same account of this locust-egg feeder, Dr. Riley says he has bred the same flies from cabbage and radish. It is probably not very common on these vegetables; we have not met with it among the hundreds of specimens of the maggots or flies from early cabbages, which we examined. Its occurrence in connection with the Cabbage Root Maggot on seed cabbage has been noted above. In 1882, the insect was found in England feeding on onions and associated with the Onion Maggot. In 1885, it was found working on the stems of young bean plants in Canada; and this year it worked serious injury in bean fields in Ohio. Dr. Linter has recently bred the insect from seed potatoes. This summer we bred the fly from a maggot found on the roots of Hedge Mustard (*Sisymbrium officinale.*)

This is an astonishing array of food for such an insect. It includes sprouting seed corn, eggs of locusts, cabbages, radishes. onions, beans, and hedge mustard. It is thus not a strict vegetarian like its near relatives; and, when sucking locust eggs, it is a very beneficial insect. Mr. Meade writes Dr. Lintner recently: "It is very curious that it should feed both upon animal and vegetable food. Some Muscids (in larva state) eat decaying (rotten) animal and vegetable matter, but I was not aware that they would feed upon them in the fresh state."

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[*] I am indebted to Mr. L. O. Howard, United States Entomologist, for the privilege of examining Mr. Coquillett's manuscript notes on the synonomy of *fusciceps* Zett., included in which I found this "Seed-corn Maggot;" doubtless the reference was made from an examination of Dr. Riley's types.

In a collection of Anthomyiians recently received from Mr. Fletcher I found a female fly which bore the label: "Bred from Indian Corn, destroying the sprouting seed," with no date. My notes on this specimen, made at the time, read: "Probably a female of *Phorbia cilicura*,"=*P. fusciceps*.

None of the popular names which this insect has received adequately express what such a name should. It would be difficult to get a name that would suggest such a variety and diversity of food habits. We therefore propose a popular name—the Fringed Anthomyiian—which was suggested by a peculiarity which distinguishes the adult male insect from other American Anthomyiians.

The fly very closely resembles the Onion Fly, but is considerably smaller.

The character by which this fly can be distinguished and separated from all other Anthomyiians is to be found in a row of short, rigid, bristly hairs of almost equal length on the inside of the hind tibiæ of the males, as shown at *c* in figure 6. Thus the popular name—the Fringed Anthomyiian—at once suggests this characteristic fringe of hairs of the male insect. As is shown at *a*, *b*, and *c* in figure 6, this "fringe" on the tibia of this insect renders it easily distinguishable from the male flies of the Cabbage Root Maggot and the Onion Maggot; the fly of the Root Maggot also has no similar armature on its hind legs. The females of this species can scarcely be separated from allied Anthomyiians unless found in connection with their males; usually the smaller size of the female of the Fringed Anthomyiian will distinguish it from the Cabbage and Onion Flies.

The maggots of this Fringed Anthomyiian very closely resemble the Onion Maggots. The only differences we find (from a study of only two or three specimens of each species) are in the size of the full grown maggots, and in the number of divisions of the cephalic spiracles.

The maggots of the Fringed Anthomyiian are considerably smaller, and there is apparently only 6 or 7 divisions in their cephalic spiracles, one specimen having 6 in one spiracle and 7 in the other; there are usually 11 or 12 divisions in the Onion Maggot. The figure of the caudal end of the Onion Maggot, at *d* and *e* in figure 6, will represent equally well the same portion of the maggot of this species, so far as our few specimens indicate.

Thus these two species are closely allied in both their adult and larval stages, and both feed on the onion, "passing through their transformations at the same time," says Mr. Meade. However, there need now be no confusion of the adult male insects, and doubtless, when larger numbers of fresh specimens of the maggots are examined, characters will be found to readily distinguish them.

The life-history of this Fringed Anthomyiian is doubtless very similar to that of the Cabbage and the Onion Flies; in its beneficial role of sucking locust eggs, it may differ somewhat. Thus, with a similar life-history, the methods recommended for combating the Cabbage Root Maggot when it attacks radishes, will prove equally effective against this Fringed Anthomyiian should it ever occur in destructive numbers, which it seems not to have yet done.

RELATION OF THE PEST TO THE "CLUB-ROOT" OF CABBAGE.

The peculiar affection of cabbage roots shown in figure 7 is familiar to gardeners as the "Club-root;" "Club-foot," "Clump-foot," or "Clubbing" of cabbage. It is an old enemy, having been known in Europe for more than a century, and American cabbage growers have suffered from it for at least half a century. The total loss from this disease aggregates thousands of dollars annually; it is particularly destructive in the eastern truck gardens in the vicinities of the large cities.

For many years after the disease was known to exist, it was believed to be caused by insects. And this is not to be wondered at, for often various insects are found in such intimate connection with it that its cause would naturally be attributed to them. The insect that is most often found in connection with the Club-root in this country is the Cabbage Root Maggot. In England the Turnip and Cabbage Root-gall Weevil (*Ceutorhynchus sulcicollis*) also occurs with the Club-root.

The maggots of this last insect cause round gall-like swellings on the roots within which they feed; and by the casual observer these weevil galls might easily be confounded with the Club root. But these galls are commonly regular in formation, like rounded smooth knobs, and on cutting them open one does not find a mass of disorganized tissue as in Club-root, but there is a central chamber which has been gnawed out by the maggot then to be seen lying within or which may have recently left through a distinct exit hole to go into the soil to transform. Thus, these galls made by weevils ought to be easily distinguished, wherever found, from the gall-like swellings of the Club root.[*]

Previous to 1876, in the books and newspaper writings of American gardeners, the Club-root of cabbages was usually associated with, and recorded as being caused by, the Cabbage Root Maggot. Peter Henderson was one of the foremost believers in this idea; and in his 1887 edition of "Gardening for Profit," although he seems to have abandoned his idea of its being caused by this maggot, yet he attributes Club-root to *an* insect, but does not say what one. The disease caused much speculation among scientific observers for many years before its true cause was discovered. The lives and habits of the insects sometimes found accompanying the disease were studied carefully, but all efforts failed to convict any of them of being the author of the injury. Finally, after three years (1873–1876) of exhaustive and painstaking labor, an European botanist, M. Woronin, explained the nature and cause of the disease. He showed it to be caused by a low form of fungous growth, one of the Slime Moulds (*Plasmodiophora brassicæ*). Other investigators have since studied the disease and all agree that it is primarily caused by this Slime Mould.

Thus, while there is no doubt that the Cabbage Root Maggot is often found attacking Club-rooted cabbage, it is also a fact that the maggots destroy thousands of plants where there is no trace of Club-root; and it is also true that the Slime Mould of Club-root is the sole cause of the death of thousands of plants in fields where there are no maggots. Thus the Club-root of cabbage is a disease of itself entirely distinct from the work of the Cabbage Root Maggot or any other insect.

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[*] *Ceutorhynchus rapae* Gyll. has been recorded injuring cabbages in Missouri by Miss Murtfeldt (Rept. of U. S. Entomologist for 1888, p. 136; also Bull. 30 of the Ent. Div., p. 50). We have found a closely allied species, "perhaps new" says Dr. Horn, doing great damage in fields of seed cabbage on Long Island. The grubs burrow in the pith of the seed stalk and its branches. Often hundreds occur in a single stalk, and sometimes whole fields of seed cabbage are ruined by the stalks wilting and breaking over just before the seed begins to mature; thus nearly the whole crop of seed has sometimes been lost by the depredations of this Seek-stalk Weevil (*Ceutorhynchus sp.*). We have found what is probably the same species of insect exceedingly numerous here at Ithaca boring in the stems of the Shepherd's Purse, the Common Winter Cress, and the Hedge Mustard; in fact, nearly every plant of the above weeds found near the insectary in July had their pith riddled by the maggots of this borer. The cabbage seed growers on Long Island thought that this stalk borer was the Cabbage Root Maggot; the maggots having simply continued on up the stem into the pith of the seed stalk. We found no Cabbage Root Maggots in the seed stalk, but they occurred in company with the Fringed Anthomyiian and other maggots on the buried stem of the plant.

This Cabbage Seed-stalk Weevil is a very serious pest in this great seed-region on Long Island and should be carefully investigated We found it difficult to breed here in the insectary, and thus far have learned but little regarding its life-history and habits. At present we can suggest no more practical method of combating the pest than to keep the fields free from Cruciferous weeds, and remove and burn all infected seed stalks as soon as noticed; after a little experience, these stalks can probably be easily distinguished from the others.

However, it still seems to be the general belief among American entomologists that either "there can be but little doubt but that the work of these larvæ (Cabbage Root Maggots) is one of the several causes of 'Club-root' of cabbage," as Dr. Riley said in 1884; or that "they sometimes cause the roots to thicken up and become malformed, producing an effect similar to that of the fungus causing the disease known as 'Club-root,'" says Weed in his "Insects and Insecticides." Our observations of the work and habits of the maggots in the field and in the insectary lead us to believe with Miss Ormerod (Rept. for 1892, p. 143) that the maggots "bore into the roots and cause mischief, sometimes to a very serious extent, by the decay thus originated, as well as by their destructive gnawings; but they do *not* cause gall growths, nor do they cause the diseased, enlarged growth which we see in the case of 'Finger-and-Toe,' or 'Club.' * * * (p. 159). The Club is *entirely and absolutely* distinct in its nature from any insect attack." True, as the same author says, the cabbage stalk or turnip root may swell slightly and often become putrid from the attacks of the maggots, and under these conditions

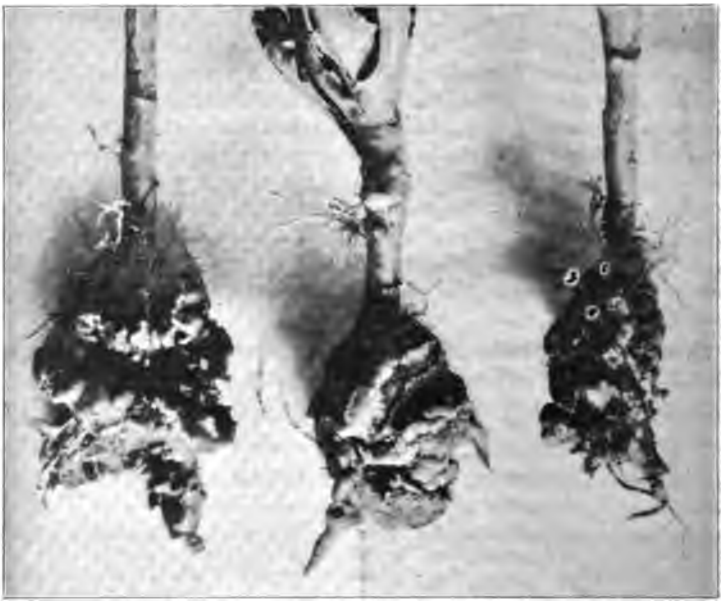

FIG 7.—"*Club-rooted*" *Cabbages; about ½ natural size.*

might be mistaken by the casual observer for the beginning stage of the Club-root attack. But the gall-like stage of the fungus is soon reached, when it should be easily distinguished from the possibly slight swellings with their accompanying maggots.

In short, the only relation of the Cabbage Root Maggot to the Club-root is that it is often found associated with it, and perhaps feeding upon or even within the gall-like excrescences produced by the Slime Mould. However, the Club-root is a disease entirely distinct from the maggot attack and the maggot is not one of the causes of the disease, for although both sometimes thus occur in intimate connection, they also frequently occur entirely independent of each other, in this case producing effects on the roots that could scarcely be confounded.

THE LIFE-HISTORY OF THE PEST.

But little has been added to our knowledge of the life-history of the Cabbage Root Maggot since it first became known in the early part of the century. Curtis, Fitch and Fletcher have added a few details regarding the method of oviposition, and habits of the maggots and flies. And yet our observations indicate that there is still much to be learned of the habits and life-history of the pest, especially during the latter part of the summer.

Our observations on its life-history have been carried on mostly at the insectary. Unfortunately, and much to our surprise, we have had but little success in breeding the insect in our cages. And as our base of operations was so far away (the extreme eastern end of Long Island), but few field observations were practicable. However, our investigations have brought out some new and surprising facts which should be supplemented by a careful study of the pest in the field. We believe there are several phases of the insect's life that are not yet understood, which would repay careful investigation.

Its first appearance and habits in the spring.—No one seems to have recorded any more definite time than early in the spring for the first appearance of this pest for the season. The form in which the pest always appears at this time is that of the adult insect. From whence they come is discussed later under the subject of hibernation. Of course, the date of the appearance of the flies in the spring will depend somewhat upon climatic conditions, latitude, and the locality. This year they appeared on Long Island in the latter part of April and during the first week in May. The cabbage plants were set about April 18, somewhat later than usual, gardeners said. Sometimes the pest has appeared early enough to attack plants before they are removed from the seed beds.

In 1826, Meigen said the flies were common in the spring on the blossoms—the familiar "pussies"—of willows. Doubtless further observations on this point will show that they frequent any other blossoms that are accessible so early in the spring.

Mr. Fletcher seems to have more closely observed the habits of the flies about cabbage plants than anyone. He says, "The females will spend a good deal of time running over the earth and trying to find some crevice" in which to oviposit.

If gardeners who are troubled with this pest will closely watch their plants for a few days after setting out, they cannot fail to observe these little flies, resembling house-flies but smaller, on and around the plants. If the flies seem at all numerous, the grower may expect trouble from their progeny and should act accordingly. Whenever the flies are seen, a day or two later the next stage of the insect, the egg, may be found.

Oviposition.—Many observers have seen the eggs and described their method of oviposition, and yet, strangely enough, there is hardly a clue in the literature as to what these eggs are like. In laying their eggs, Mr. Fletcher says the females spend some time in "trying to find some crevice by which they can creep beneath the surface of the soil and lay their eggs close to the stem, or they will creep close up to it and push the eggs down below the surface by means of their extensile ovipositor." (In figure 5, plate I, this ovipositor is shown partly extended from the end of the abdomen of the female fly.) Some observers say the eggs are laid on the surface of the soil; this may happen where the soil gets packed closely about the stem, leaving no crevice.

A correspondent wrote the "Rural New Yorker" in 1887, that he watched the flies carefully in the spring and found that all the eggs were laid about his cauliflower plants within 4 or 5 days' time. They are laid one to twenty on a plant, close to the stalk on the soil and are readily seen with keen eyes. In 1887, Prof. Cook recorded finding hundreds of eggs about a single plant. This is no exaggeration, for we have found at least 300 maggots at work on a single cabbage plant.

Several flies must lay their eggs on one plant to produce such a crop of maggots; and when only 10 or 20 maggots occur, a single fly must oviposit on several plants. This statement is based on the following observations. April 9, a female Cabbage Fly emerged in a cage in which young cabbage plants were growing here at the insectary. She laid no eggs, and died on April 13. An examination was made of the contents of the abdomen, and it was found to be packed full of eggs. Fifty-five of these, apparently fully developed, eggs were removed one by one, before the abdomen was emptied; no partly developed eggs were seen. Thus 55 is probably about the normal number of eggs laid by one fly.

Although the eggs are very small, measuring only .04 of an inch (1.1 mm.) in length, their whitish color renders them quite easily seem by keen eyes, lying as they do close to the stem of the plant with the dark soil as a background. One of these eggs is shown greatly enlarged at *a* in figure 8. The minute hair line near the centre of *b* represents the natural length of an egg. *b* in the figure represents, in outline, the shape of the egg when viewed from the side. When examined under a microscope the egg shell presents the curious irregularly ridged appearance as shown at *a* in the figure. The figure also shows the large deep groove which runs along its whole length becoming deeper as it approaches the blunter or head end of the egg.

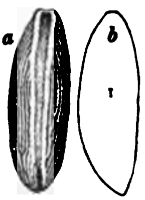

FIG. 8.–*a*, *the egg, greatly enlarged; the hair line near the center of b represents its natural length. b, outline of side view of an egg.*

Apparently all writers have followed Taschenberg (1865), in stating that the eggs hatch in about ten days. Mr. P. H. Scudder, of Glen Head, Long Island, who has observed this pest closely, told the writer that the eggs hatched in from four to ten days, depending upon the conditions of the weather; a cold spell retarding their hatching. Eggs began to hatch in Mr. Reeve's field at Mattituck, L. I., this year about May 8.

May 11, he sent us many of the eggs; they were sent in a box nearly full of soil, and reached us in seemingly good condition. They were at once isolated on pieces of dampened blotting paper; but not an egg hatched. This would indicate that the eggs are easily injured if much disturbed; and it may explain the success of one of the remedial measures to be discussed later.

We have had several of the flies emerge in cages of young cabbage plants, from hibernating puparia brought from Long Island; and also have had hundreds of the flies of the second brood emerge in large frame cages (figure 10) containing radish, turnip, cabbage, and hedge mustard plants. Yet the female could not be induced to lay a single egg; while flies came in from out of doors and freely oviposited on similar plants growing exposed in a bed but a few feet from the cages. Thus all our efforts to breed this insect from the egg in confinement, have thus far been unsuccessful.

Habits of the first brood of maggots.—In emerging, the maggot pushes through the blunter end of the egg which splits down along the sides of the deep groove. The young maggots at once attack the surface of the root. By means of its strong, curved, hook-like mouth parts shown much enlarged in figure 9, it soon rasps out a burrow along the surface. The tender rootlets seem to be the first objective point of the young larvæ. These destroyed, the maggots turn their attention to the main root into which they burrow, often girdling it as shown in figure 1. The figure on the front of the bulletin shows the maggots at this work, and their effect on a cabbage root.

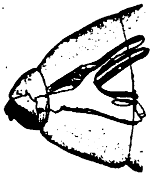

FIG. 9.—*Mouth parts of the maggot, greatly enlarged.* (*Adapted from J.B. Smith.*)

Usually the maggots are found in slimy burrows in the bark just beneath the surface; and sometimes one is found just entering the bark, "with the end of its body projecting stiffly out, like a peg driven in half its length," as Dr. Fitch describes it. The interior portion of a rather large cabbage root is so woody that the maggots do not often work in it, but they sometimes penetrate into the interior of the softer stem farther up. When but a few maggots occur on a root, they are usually to be found in their burrows; but often so many maggots attack one plant that as they increase in size there is not room for all in the bark. In this case, as Mr. Fletcher says, "most of them lie outside in the soil, which is kept wet by the juices of the injured plant." Where we have seen this state of affairs, the maggots were nearly full grown and the plant had toppled over. Thus, all the maggots doubtless had access to the plant for food during much of their life, but probably they were being nourished by the juices exuding from the injured plant when found. When this stage in the ravages of the maggots is reached, on a cabbage plant especially, the slimy mass of soil and the then rotting roots combine to give out one of the most sickening odors imaginable.

The maggots work in a similar manner on radishes and turnips, except that often their slimy burrows extend irregularly about in the interior of the succulent root. Gardeners attribute much of the toughness and stringiness of turnips and radishes to the work of these maggots.

In 1878 Dr. Riley found the maggots not "only working in the normal way on the roots, but also burrowing in the stout mid-ribs of the leaves." Mr. Fletcher noticed a few of the maggots working in a similar manner at Ottawa in 1890.

Most writers, following Bouché, state that the maggot stage lasts from three to four weeks. Mr. Whitehead of England says from 24 to 28 days. We have no definite record on this point, but our observations indicate that under favorable conditions many of the maggots of this first brood attain maturity in less than three weeks.

The cabbage plants in our experiment plot on Long Island were not set until April 18 this year, but we bred a few flies as early as May 29 from maggots taken from some of these plants; thus the egg, larval, and pupal stages must have been passed in less than 41 days. Most of the maggots of this first brood matured during the last week of May and the first few days of June this year on Long Island. But maggots of various sizes occurred May 20. This was doubtless due to some of the flies appearing and ovipositing later in the spring than others.

Pupation.—When the maggots get full grown, they usually work their way for an inch or two into the soil away from the roots, and there enter the pupal stage. Sometimes this change takes place in the galleries which the maggots have made in the roots. The change from the maggot to the pupal stage is quite gradual. The casual observer would notice but little difference between a full grown maggot and a puparium which was only an hour or two old; they are of the same color, but the latter is a little shorter, slightly more elliptical in shape, and shows a certain stiffness not seen in the maggot. These puparia can be easily found if the soil around the base of a badly infested plant be closely examined, for a depth of two or three inches, at almost any time from June 1 until the next April.

In an hour or two after the puparium is formed, the skin begins to turn brown, and usually reaches a light cinnamon color in eight or nine hours. Some do not get much darker, but others pass to a dark seal brown color. They vary considerably in size, some being a third smaller than others. It was at first thought that this might be a sexual difference, but both sexes of the flies emerged from some of the smallest ones isolated for the purpose.

The duration of the pupa stage is stated by most authors to vary from two to three weeks in the summer. Mr. Whitehead says sixteen days. Dr. Riley records the appearance of the flies after only eight days of pupation. Most of the puparia under our observation gave out the flies in about twenty days, in June; with some it lasted only fifteen days, with quite a number nearly two months, with others three months, and from a few the flies had not emerged by September 5, or three and a half months after the puparia were formed. These are very surprising facts when one understands that all of these purparia came from the first brood of maggots. There is no hint in the literature of any such retardation in development. Yet our observations are conclusive.

For instance, nine puparia were put in a tumbler May 23, and flies emerged and were removed on the following dates, one on June 7, one on June 8, three on June 10, one on June 14, one on August 18, and one on August 23; one puparium was opened August 18 and it contained a fly pupa. These dates also correspond very closely with our notes on the appearance of the flies in our larger cages (figure 10), where hundreds of them emerged during the summer.

This state of affairs complicates matters, especially as regards the later broods of the pest. It is even possible that some of the first brood of puparia hibernate. We comment further on this phase of the subject when we discuss the number of broods of the insect.

Habits of the flies in summer.—When the pupa is fully mature, it crowds against one end of its brown home, which soon splits open and allows the fly to emerge. As Dr. Fitch says, it "crawls up out of the ground, with its wings crumpled up, and climbing up the side of a clod or any perpendicular surface which it finds, these members expand and assume their proper form before they become dried and firm." The flies are frequently to be seen resting quietly for several minutes at a time on different parts of the food-plants of the maggots. As the Anthomyiians frequent flowers, doubtless the cabbage fly will be found on the various blossoms growing in or near gardens during the summer.

How long the flies live in the summer is not known; they lived ten days in our cages in the insectary. Doubtless they live but a few days after providing for the perpetuation of the species. The flies do no damage, for if they feed at all, it is only to eat a few grains of pollen or to sip a little nectar from some flower.

The number of broods, and habits of the later broods.—It appears to be the accepted belief among entomologists that there are three or four generations or broods of this pest annually. In 1884, Dr. Riley stated that "the number of broods in the course of a season has not been accurately followed in any given latitude, but there are at least three." Many authors have simply followed Bouché who said in 1833, that there were several generations of the pest during the summer. In 1874, Prof. Cook concluded that there were at least two broods.

A search through the earlier literature of the insect has revealed the probable source of this idea that the pest passes through three or four generations annually. In 1865, Taschenberg said: "Because they (the flies) need for their complete development, which begins with the early spring, on an average eight weeks including ten days for the egg stage, therefore must three complete generations in the course of a year be accepted as normal." Thus, the number of generations has been merely a matter of calculation, doubtless based on observations made only on the first brood in the spring.

There is no doubt that a brood of flies appears early in the spring, in New York State in the latter part of April and the first week in May. These flies, and their progeny of maggots which work on the plants in May, constitute the first brood or generation of the pest. This brood appears, in greater or less numbers, in all localities where the insect occurs. And in most localities, in most seasons, both in Europe and America, it is the most destructive brood, working in early cabbages, radishes, cauliflowers, and turnips; sometimes attacking these plants before they are removed from the seed bed. We also found this brood the most numerous on the weeds upon which it feeds.

However, we find such statements as this from Dr. Fitch: "It is only my earliest sown radishes, each year, from which I obtain any that are fit for use, and for several years past, this first sowing has also been a total failure." Mr. Fyles also says that the radish fly "appears in the end of June and the beginning of July. I have found that radishes sown at Quebec in the beginning of May" are a success. Thus, in some localities, especially in Canada, and in some years the first brood of the pest is not noticeably destructive; but we believe it appears every year, in greater or less numbers, in all localities. Even in Canada, early cabbages are sometimes injured in the seed bed, says Mr. Fletcher.

The first brood is well defined; the flies appear in April and their maggots work destruction in May on the roots of the cabbage tribe, on radishes, and on turnips. The time when the first brood of maggots mature will of course vary with the season. This year, on Long Island, they matured about June 1, changed to pupæ, and a majority of the flies had emerged by June 15. This date agrees closely with the recorded rearings of the flies from maggots of this first brood. Thus the second brood begins, in New York State, with the appearance of these flies about June 15. It should be borne in mind, however, as recorded above, that all of the puparia of the first brood do not give out their flies in June; some do not appear for months after. Our observations indicate that at least 75 per cent. of the flies appear in June.

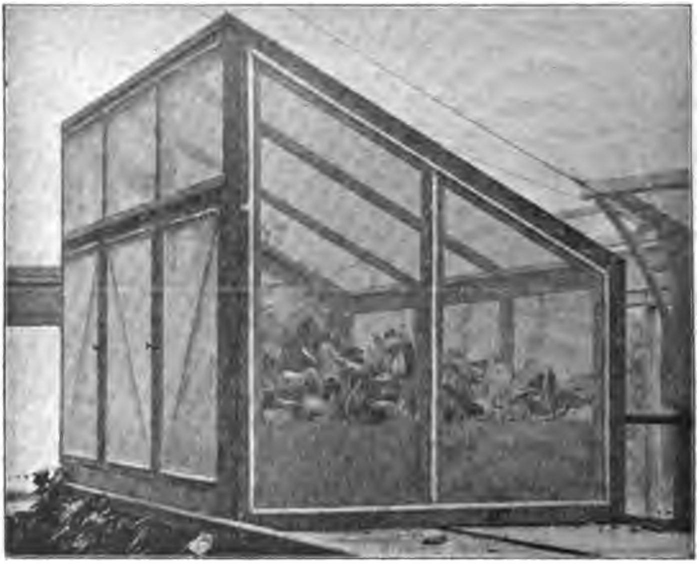

FIG. 10.—*Cage devised for breeding the Cabbage Root Maggot.*

Although hundreds of these flies emerged in our large cages prepared especially for their comfort, none laid eggs all dying in a few days. One of these cages is shown in figure 10. It consists of a framework covered with cheap tarlatan, and is screwed together for convenience in storing away. It is 7 feet long, 3 feet wide, 3½ feet high at the front and 2 feet at the back; the top being made slanting to correspond with the glass roof of the insectary. For convenience in examining all parts of the cage, three large doors were made in the front as shown in the figure. The whole frame sets over a bed of earth made in a wooden frame. In this bed the different food-plants of the pest were grown. Although this cage proved a failure as far as breeding the Cabbage Fly is concerned, it will prove a valuable addition to our outfit for studying other, less particular, insects.

In one of these cages we kept growing various sizes of cabbages and hedge mustard from May 20 to August 3; and in the other cage several varieties of turnips and radishes were grown during the same period. The plants grew thriftily, and hundreds of the flies emerged from maggots and puparia placed in the cages. But for some unaccountable reason they would not oviposit. It would seem as though in these large airy cages the flies would be sufficiently at home to provide for the perpetuation of their species. And it seemed still more strange, when we found flies coming into the insectary (which is only a similar cage on a larger scale) from out of doors in June, and breeding on radishes and turnips in a similar bed only a few feet away.

Thus our efforts to rear this second brood of the pest in confinement has this year been a failure. And yet there is no doubt that the flies of this brood soon oviposit and a second destructive brood of maggots appear in July. For in the latter part of June, we found half grown maggots at work on some of the radishes and turnips in a bed in the insectary. These were doubtless produced by flies which appeared in the early part of June, or about the time the second brood of flies appeared in the fields. Furthermore, the recorded facts indicate that in certain years in some localities, this second brood is the destructive one. The testimony of Dr. Fitch and Mr. Fyles quoted above shows this. Mr. Fletcher says in 1890: "The greatest amount of injury is caused by a brood of flies which appears in the middle of June and up to about the first week of July." Thus in Canada, the second brood is usually more destructive than the first.

The natural conclusion from the above facts is that there is a second brood of the pest, which is often equally as destructive as the first; the flies of this second brood appear about June 15, and the maggots work in July. And the second brood evidently works in the same manner on the same food-plants as does the first brood; late cabbage also often suffers in the seed bed. The exceptional habit of mining the leaves of beets, recorded by Dr. Lintner, seems to have been the work of this second brood of maggots.

The definite recorded knowledge of this second brood seems to end with the maggots in July. When do the flies which are to produce the third brood appear?

Upon pulling up a turnip in a bed in the insectary on July 5, we found several nearly full grown maggots at work on it, and in the soil near by were a few puparia. Flies emerged from these puparia, July 16 and 20; the maggots produced flies on July 29, August 2 and 21. Thus the indications are that some of the puparia of the second brood give out their flies in about 20 days, while others remain as puparia for 40 days or more. As has been mentioned, the flies from the first brood of puparia also appeared at similar irregular intervals. Possibly a majority of the flies of the third brood (that is, those flies produced from the second brood of maggots) appear in the latter part of July. And curiously enough, some, possibly 20 per cent. of the puparia of the first brood gave out the second brood of flies in our cages about July 20; there had been no maggots in the cages and no flies had appeared since the middle of June.

Thus a portion of the third brood of flies emerge in July and are seemingly reinforced by a few belated members of the second brood. From this point our knowledge of this pest, both from the records and from our observations, is very meagre and fragmentary. The flies which emerge in July would be just in time to catch the late crops of their food-plants, and often the plants are then young and tender.. But it is the universal testimony of gardeners that late crops of cabbages, radishes, or turnips suffer but very little, if any, from the maggots. Especially is this true of cabbages ; some gardeners tell us the maggots seem to prefer to work on late radishes and turnips, and that these crops are the breeding places of the later broods.

In August, when the third brood of maggots would naturally appear, the early crops of cabbages, cauliflowers, radishes and turnips have been harvested. And as the late crops of these vegetables seem to be rarely, if ever, seriously damaged, the question naturally arises, if there are later broods, where do they develop?

There is no doubt that the maggots do work on the roots of their ordinary food-plants later in the season. Many writers record the occurrence of the insect after August, sometimes even in November. In 1891, the maggots wrought great destruction in a field of turnips at Ithaca in the early part of the season; and we found a few maggots still at work on October 3. But there are apparently no records of the maggots occurring in sufficient numbers to do serious damage after August 1. Thus no well-marked destructive broods of the insect seem to appear after the second one, on cultivated crops at least. Those found at work in August and later would seem to be scattered remnants or irregular broods produced by belated flies from the first brood of maggots, augmented by some flies which emerge from the second brood of puparia in July. Curtis' observations seem to support the view that all of the flies from the second brood of puparia do not emerge the same season. Maggots working in turnips were sent him July 21. These were put, with a turnip root, in a flower-pot; but the flies did not emerge until the following April.

The above discussion indicates that the life history of this pest becomes quite complicated in July and August. We are able to definitely trace but two distinct broods of the pest, the second brood changing to puparia in July.

Hibernation.—Curtis says: "Many of the flies no doubt live through the winter, secreted in holes and crevices, and some of the pupæ do not hatch until the spring;" this is but a free translation of what Bouché wrote in 1834. All later authors agree with Bouché. In 1884, Dr. Riley said that "the insect hibernates both in the larva state in the roots and in the puparium state underground." Thus it has come to be the accepted belief that the pest passes the winter in all three of its later stages—the maggot, the puparium and the fly.

The experience of Mr. Fyles who, on November 21, examined radish roots on which the maggots were operating in October, and found no maggots, would indicate that the pest does not pass the winter as a maggot; and we are inclined to think that this method of hibernation is exceptional. For, early in April, while searching for the pest on Long Island, we examined many of these "stumps" left in the fall, but saw no indications of hibernating maggots. This point could be easily settled by some field observations in the winter or early spring.

Most observers agree that the usual method of hibernation is in the puparium. This is the form in which we found the insect early in April on Long Island. They were found in the soil around the base of "stumps" of early cabbage. However, but comparatively few were found in this situation, and we had no opportunity to examine the soil where late crops had grown. So few puparia were found that it seemed improbable that the pest would be numerous this season. But, notwithstanding the fact that the cabbage field was removed about 150 feet from last year's field, the maggots were more numerous than ever this season. This would indicate that either the pest bred freely in other late crops thus producing many puparia elsewhere, or that possibly many flies hibernated.

The indications, as shown in our discussion of the number of broods of the pest, are that possibly some of the first brood and many of the second brood of puparia hibernate, not giving out their flies until the next April.

Apparently the only evidence we have of the hibernation of the flies, is the statement of Bouché quoted above. We found but few puparia early in April, and yet the flies appeared in large numbers three weeks later. These facts would indicate that many of the flies hibernated. It is not at all improbable that the flies do pass the winter secreted in crevices or under rubbish, etc. However, there is need of further evidence on this point.

NATURAL ENEMIES OF THE PEST.

This pest, like many other insect pests, has several enemies among the animals, including those of its own kind—the insects. These natural enemies help to hold this pest in check, but the balance of nature has not yet reached that point where the scale tips in favor of the enemies. However, they are worthy of consideration, for the time may come when they will effectually check it.

Of the larger animals, two are recorded as feeding on the maggots. In the *Country Gentleman* for 1864, a correspondent is advised to turn his chickens into his cabbage patch to destroy the maggots. At one end of our experiment plot on Long Island, chickens injured some of the plants soon after they were set out. Later, when the maggots had appeared in full force, the chickens found them, and thousands of them were eaten, but usually the plants were also either pulled up or badly damaged. Thus, on the whole, it is hardly advisable to try to fight this pest with chickens, unless the plants are already beyond recovery.

In England, as Miss Ormerod reported in 1884, the Rooks sometimes tear up infested plants and hardly a maggot escapes them.

Several insects have been recorded as enemies of the Cabbage Root Maggot and allied insects.

In Europe, five different species are recorded as parasites on Anthomyiians. In 1834, Bouché enumerated the following: *Alysia ruficeps*, from the pupæ of *Anthomyia radicum; Alysia manducator*, from the pupæ of *Athomyia dentipes; Microgaster anthomyiarum*, from the larvæ of *Phorbia ceparum; Figites anthomyiarum*, from the pupæ of several species of *Anthomyia*, as *dentipes*, *floralis* (=*brassicæ*), etc. Taschenberg says: "The small Braconid *Opius procerus* Wsml. was bred from the larvæ by Mr. Brieschke." All of these insects are minute active wasp-like forms, which doubtless crawl into the earth among the maggots and sting their eggs into the bodies of their helpless victims.

Probably none of the above parasites work on the pest in this country; but in 1888 Mr. Gillette discovered that a similar minute Hymenopterous insect was at work on the pest here.

The description of this parasite has not yet been published, but Mr. Fletcher has given it the name *anthomyiæ;* it is one of the Cynipids belonging to the genus *Trybliographa*, which European authorities consider to constitute a section of the genus *Eucoela*. In 1893, Mr. Fletcher bred this little parasite in considerable numbers from the puparia of the Cabbage Root Maggot. This year we have bred a few from puparia brought from Long Island. The adult parasite appeared in Mr. Gillette's cages in September from puparia of the first brood found in June. A specimen, recently received from Mr. Fletcher, bore the date, April 15. We bred two of the parasites in August from puparia of the first brood, and an examination of other puparia of this brood to-day (November 6) reveals several which contain no trace of the Cabbage Root Maggot, but instead a broad, fat, much wrinkled, footless, whitish grub that is doubtless the larva of this Cynipid parasite which will probably hibernate in this condition. Probably the eggs of this little foe are laid in the maggot before the puparium stage is reached. In emerging from the puparium, the little wasp like fly broke through an irregular, nearly square hole just back of the head end.

This little Cynipid has thus been found in Michigan, Canada, and New York, and it doubtless has quite a wider range, possibly occurring in most localities where the maggots work. It may play an important part in keeping this pest in check in the near future.

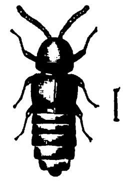

FIG. 11. — *The beetle which preys upon the Cabbage Root Maggot: the hair line at the right represents its natural length. (From Lintner)*

The little Hymenopterous parasite just discussed has a worthy rival in the form of a small beetle, one of the *Staphylinidae*, or Rove Beetles. Many of these narrow short-winged beetles are very useful as scavengers, some attack living insects, and others are parasites in ant's and wasp's nests. The one which has found the Cabbage Root Maggot very palatable food is very small and slender, measuring only about ⅙ of an inch in length. The beetle is represented in figure 11, considerably enlarged; the hair line at right shows its natural length. It is black in color, and its body is covered with silky hairs and small punctures. These hairs and punctures being so much less numerous on the head, thorax, and first four antennal joints, cause these parts to appear blacker than the rest of the insect. Sometimes the wing-covers have a greenish coppery lustre. The feet are brown, the femora and tibiae blackish. The terminal joints of the antennae are so thickly covered with the short hairs as to have a grey appearance.

This little foe received its name, *Aleochara nitida*, in Germany in 1802. There are also frequent references to it in later systematic works by Europeans, thus indicating that it is widely spread and doubtless common in various parts of Europe. It has been known in this country since 1836, when Say described it from Missouri as *Aleochara verna*; this name was made a synonym of *nitida* by Le Conte in 1869. In 1870, Mr. Sprague found the beetle in Massachusetts, and being advised that it was a new species described it as *Aleochara anthomyiae*, by which name it has since been discussed by American economic writers. However, for nearly ten years, the insect has been considered identical with *nitida* by systematists (Henshaw's List of Coleoptera). In America the insect is now known to occur in Missouri, Massachusets, New York, and Canada. It thus has a wide distribution both in Europe and in this country.

Nothing seems to have been recorded of the habits of this little beetle until 1870, when Mr. Sprague published the following account:

"I took from the earth in my garden, around the root of a dead cabbage plant, twenty-six pupae of the Cabbage Maggot, from which I bred two imagoes; also six parasites which came out of the pupa-cases by gnawing a rough hole through the side near the extremity, after which I took from the remaining pupa cases three imagoes, and one pupa of the Rove-beetle. My surprise was so great upon discovering the six Rove-beetles where I expected two-winged flies, that I carefully examined with a microscope the remaining pupa-cases, as also those from which the flies came, but could discover no break or orifice by which the Rove-beetles could have entered. It was after this examination that I opened the balance with the above stated results; thus proving, so far as I can judge, that the fly larva was entered before its skin had hardened into the pupa-case."

In 1880, Mr. Barnard found the beetle very abundant here at Ithaca. He says:

"They are often seen running from one young cabbage to another, or entering holes, but more commonly close about the stalk. Half of our young cabbages here, last year and this, have been killed by the maggots, and now on pulling up an infested stalk, these beetles often come out, sometimes several from about one plant. To test their habits, I put a maggot in a bottle with them. When hungry a single one alone will attack a full-sized maggot, tearing open its sides and feasting upon it. I have seen five of them like a pack of wolves, cling to and tear a writhing maggot, killing it quickly. They are wonderfully active, and promise to be the best enemy against the fly which has ruined so many crops here."

Four years ago Mr. Fletcher made the following observations on the habits of this relentless foe of this cabbage pest:

"This little friend . . . was found in considerable numbers running about among the cabbages and burrowing down beneath the soil in search of maggots. Not only is it extremely active in preying upon the maggots, but it is also a true internal parasite feeding inside them and completing its transformations inside the pupa case. In the hope of rearing this beetle, 16 larvae and pupae were taken from the root of a cabbage, where the perfect beetle had been seen and were inclosed in a breeding jar. From these were reared 9 beetles and one fly, the remainder of the pupae dried up without coming to maturity. In some of them, however, the immature beetles were found when the cases were broken. When the beetle eats it way out of the pupa-case it gnaws a ragged hole at one end quite different from that made by the emergence of the fly. . . . . I have generally been able to find a few of these beetles in beds of cabbages infested by the Cabbage Maggot and upon one occasion bred a specimen from the Onion Maggot."

These accounts of the habits of this beetle indicate it works destruction to the Cabbage Root Maggot both as a parasitic larva and as a predaceous adult. Both Mr. Sprague's and Mr. Fletcher's accounts would seem to show conclusively that this Staphylinid beetle is a true parasite. And yet, closely allied forms are known to have strictly predaceous habits. In 1888, Mr. Coquillett saw a larva of *Maseochara valida* "busily gnawing its way into a puparium of a Syrphid fly. At the expiration of 24 hours it had completely buried itself in the interior of the puparium, and I saw nothing more of it for a whole month, when it issued through an irregular hole in the upper side of the puparium and soon afterwards spun an irregular, thin, tough, white cocoon in the bottom of the breeding cage. The beetle issued about 11 weeks later." At the meeting of the Association of Economic Entomologists in 1891, Mr. Schwarz, who has a wide knowledge of the habits of beetles, said that he "considered the larva of these beetles not to be true parasites, but simply predatory, . . . and stated, moreover, that the beetle larva has no approach to the parasitic habitus."

Thus theoretically, this enemy of the Cabbage Root Maggot should be purely predaceous in its habits, but practically the evidence of competent observers seems conclusive that it is truly parasitic. As we have not met with the beetle in our observations, we can offer no evidence in support of either opinion. The evidence both pro and con, has been quoted in full, with the hope that it will stimulate future observers to carefully investigate this point whenever they may be fortunate enough to find this little enemy at work. There is no doubt that man has a most potent ally in this little beetle.

The Cabbage Fly has still another enemy in the shape of a mitè, a species of *Trombidium;* it resembles its near relative, the well-known Red Spider so common on house plants. In 1887, this little mite, which would escape detection except by the keenest eyes, was found in Michigan sucking the eggs laid by the Cabbage Fly. It was found that three of the mites would suck, on an average 28 eggs every day. No similar observations have since been recorded.

Thus, in this country, man is aided in his warfare against this most formidable cabbage pest by the chickens, by at least two common and widely distributed foes among its own kind as the Staphylinid beetle and the little Hymenopterous parasite, and by a mite. However, these foes apparently have not yet gained sufficient strength to effectively check the Cabbage Root Maggot in its destructive work. The time may come when the balance of nature will turn in favor of these little foes. Thus the gardener needs to be acquainted with these little friends of his that he may protect them whenever they are found " lending a hand."

METHODS OF PREVENTING THE RAVAGES OF THIS PEST.

About 70 different methods have been recommended for combating this pest. Our experiments and a study of recorded experiments, lead us to believe that only 6 of these need be, at present, seriously considered by gardeners. They are therefore discussed first, in large type, as the Effective methods, two of which act as preventives, and the others are used to destroy the insect.

We group 9 of the proposed methods as Doubtful, or Partially Effective; 3 of these are preventives of attack, and 6 act destructively.

The remaining methods, about 50 in number, we class as Ineffective, or Impracticable methods, about one half of which are supposed to be preventive in their action, and the others destructive. Some of these deserve further notice by future experimenters.

This full discussion of all methods recommended to combat this pest will enable gardeners and others to decide *what not to use, what is worthy of a trial, and what methods have been found practicable and effective.*

1. EFFECTIVE METHODS.

A. PREVENTIVE.

1. BY MECHANICAL DEVICES.

(a) *Covered Frames over Plants.*

This method of growing the plants, either in a cold frame covered with cheese cloth or fine netting, or under a similar protection in the field, is of course, only practicable with small areas or a few choice plants. Prof. Cook grew radishes successfully in this manner in 1888. Wherever practicable it will prove a sure preventive, but must be applied early before the flies appear and be kept on during nearly the whole season.

(b) *Tarred Paper Cards.*

This idea of preventing the attacks of the Cabbage Root Maggot by closely encircling the stems of the plants by paper collars resting upon the ground, first originated in Michigan in 1887. Prof. Tracy, of Detroit, experimented with heavy manilla paper, but not with satisfactory results. Prof. Cook also experimented with the paper cards, and although he secured hundreds of eggs where he used adhesive fly paper for the cards, yet he could not recommend the method; he seems not to have tested it again.

In the spring of 1889, the idea occurred to Mr. Goff to substitute for the manilla paper, cards made of tarred paper, and further protection was secured by the use of a bit of grafting wax to form a more perfect union between the paper and the stem. His experiment was a complete success.

This preliminary experiment was so successful that the next season Mr. Goff perfected the method by devising a very simple tool which would cut, at a single operation, a six-sided card with a slit reaching to the center, and with a star-shaped cut at the center, so that the same card may accommodate itself to any sized stem and still make a tight joint. He had these cards tested by several large cabbage growers that season. Mr. J. M. Smith, of Green Bay, Wis., reported that he had about 7,000 plants protected with the cards and secured a splendid crop; while a like number of unprotected plants nearby would have been an entire failure if he had not resorted to the hand-picking of the maggots. Messrs. Smith Brothers of the same place also reported a like success from the use of the cards. In 1891, these same parties again used the cards. The former reported that he lost from the maggots not more than 25 plants of the 10,000 to 15,000 that he protected with

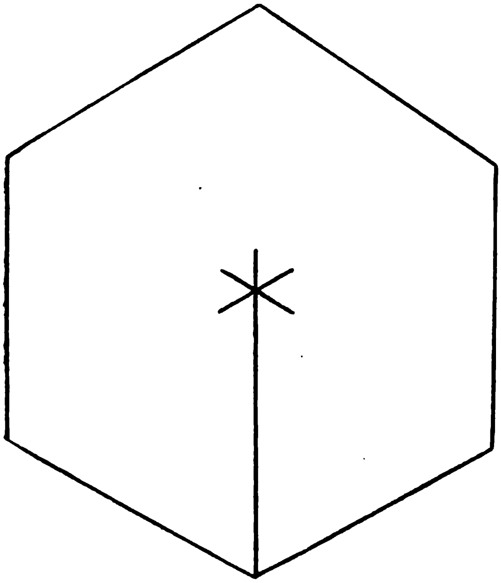

FIG. 12.—*Outline of Tarred Paper Card; natural size.* (*From Goff.*)

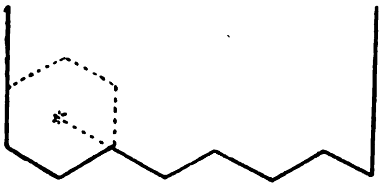

FIG. 13.—*Diagram showing how the tool is used. The dotted line indicates the position of the edge of the tool.* (*From Goff.*)

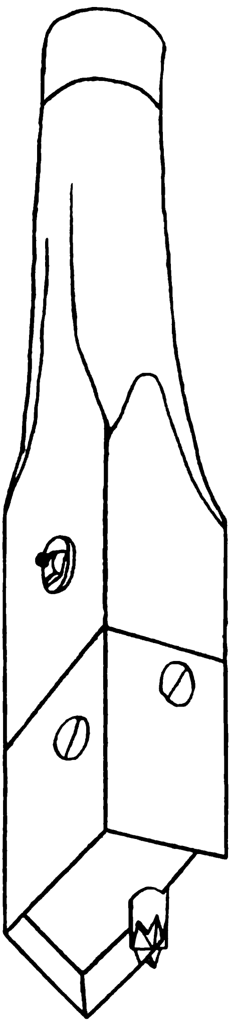

FIG. 14.—*Tool for cutting the cards; about ½ natural size.* (*From Goff.*)

the cards; ordinarily he would have lost from ¾ to $\frac{9}{10}$ of the crop. Messrs. Smith Brothers used about 15,000 of the cards and had no maggots, except where the cards were not properly put on.

These experiments having established the practicability of the tarred paper cards, the method was published by Mr. Goff in 1891. We have reproduced Mr. Goff's outline drawings of one of the cards (Fig. 12) natural size, of the cutting tool (Fig. 13) about ½ natural size, and of the diagram showing how the tool is to be used (Fig. 14) much reduced. We quote Mr. Goff's concise descriptions of the cards and tool, and their use: "The cards are cut in a hexagonal form, in order to better economize the material, and a thinner grade of tarred paper than the ordinary roofing felt is used, as it is not only cheaper, but being more flexible, the cards made from it are more readily placed about the plant without being torn.

"The blade of the tool, which should be made by an expert blacksmith, is formed from a band of steel, bent in the form of a half hexagon, and then taking an acute angle, reaches nearly to the center, as shown in figure 14. The part making the star-shaped cut is formed from a separate piece of steel, so attached to the handle as to make a close joint with the blade. The latter is beveled from the outside all around, so that by removing the part making the star-shaped cut, the edge may be ground on a grindstone. It is important that the angles in the blade be made perfect, and that its outline represents an exact half hexagon.

"To use the tool, place the tarred paper on the end of a section of a log or piece of timber and first cut the lower edge into notches, as indicated in figure 13, using only one angle of the tool. Then commence at the left side, and place the blade as indicated by the dotted lines, and strike at the end of the handle with a light mallet, and a complete card is made. Continue in this manner across the paper. The first cut of every alternate course will make an imperfect card, and the last cut in any course may be imperfect, but the other cuts will make perfect cards if the tool is correctly made, and properly used.

"The cards should be placed about the plants at the time of transplanting. To place the card bend it slightly, to open the slit, then slip it on to the center, the stem entering the slit, after which spread the card out flat, and press the points formed by the star-shaped cut snugly around the stem." At *a* in figure 16 is shown a card properly applied to the stem of a geranium; *b* shows a card carelessly put on.

Mr. P. J. Diepold of Madison, Wis., has made several of the cutters; he charges $2.50 each, and makes a very satisfactory tool. The best grade of paper to use is what is termed "one ply tarred felt." It can be bought in retail lots for from 2 to 4 cents per pound. The following letter published by Mr. Goff gives reliable data as to the cost of the cards, the labor of applying them on a large scale, and other useful hints:

GREEN BAY, Wis., April 12, 1894.

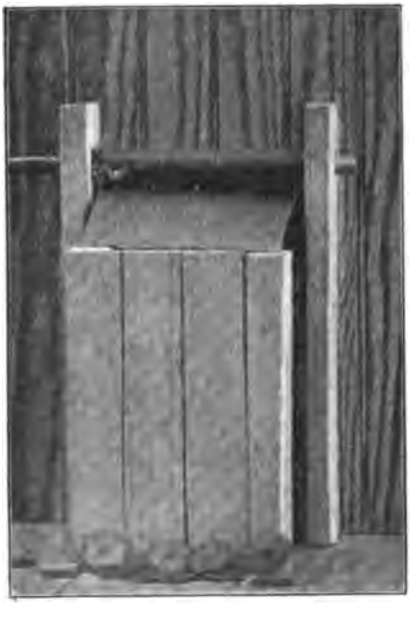

FIG. 15.—*An arrangement for facilitating the cutting of the cards.*

Our young man cuts from 500 to 600 of the cabbage pads per hour or 5,000 to 6,000 per day of ten hours. One person will put on from 300 to 500 per hour according to the rapidity of the workman. The paper that we use costs from 1¼ to 1½ cents per pound at wholesale, or from 2½ to 3 cents at retail, and one pound makes about 200 pads. In giving instructions to anyone in regard to using the pads, always caution them about getting the pads too low down, for if they are covered with enough earth so that the earth above the card remains moist, the maggots will work over the pads. We had one bed of cabbage two years ago that illustrated this point in the most perfect manner. The bed extended from ground that was quite firm to some that was very soft, and in the soft part the boys set the plants too low and the earth gathered in over the pads and the maggots got their work in according to the amount of earth there was over the pads. On this same bed I made an experiment without and with the pads and the result proved, as it had before, that beyond all question the pads do all that we have claimed for them. GEO. B. SMITH.

Mr. Smith has described for us his arrangement for cutting the cards. He says: "We put the roll of paper on a roller made by standing two pieces of plank up edgewise to the wall, fastening them in position, and boring an 1½ inch hole in each; a hoe handle put through the hole in the roll of paper, serves as a roller. The cutting block is made wide enough to work the whole width of the paper by fastening several blocks of hard wood together; it is then stood on end immediately in front of the roller." This arrangement is shown in figure 15. Where large numbers of the cards are to be cut, some such device would facilitate the work very much.

Being very favorably impressed with this preventive method devised by Mr. Goff, we planned to further test it on our experiment plot on Long Island. A diagram and description of this plot is given on page 551. The diagram represents the rows on which we planned to put the cards. They were put on April 19, the day after the plants were set. Mr. Reeve, the owner of the plot, applied the cards quickly and quite well for one with no previous experience. May 21, we examined the plot. It required but a glance over the field from the west end to determine which rows had been treated with the preventives, and especially was this true of those protected by the cards. However, as we glanced along the 4th, an untreated row, and the 5th, a treated row, it soon became evident that either the cards had offered but little protection to the plants in the east half of the latter row, or that we had not followed the plan. For the east half of the 4th row, which should have had but few plants standing, judging from the other untreated rows, showed nearly all the plants in good condition. Further examination showed that we had make a mistake and the cards had been applied to the east half of the 4th row instead. Thus the preventive experiments were planned as in the diagram on page 551 but were applied according to the following diagram:

NORTH.

	WEST.	EAST.
1st row :	Tobacco Dust	Paper Pads.
2d row :	untreated	untreated.
3d row :	Paper Pads	Carbolic Acid Emulsion.
4th row :	untreated	Paper Pads.
5th row :	Carbolic Acid Emulsion.	untreated.
6th row :	Paper Pads	Tobacco Dust.

SOUTH.

This mistake only served to bring out more strongly the effectiveness of the cards.

When the examination was made (May 21), the maggots had done their worst, and scarcely 50 plants remained standing in the untreated rows, while less than 50 had succumbed in either of the two rows protected by the cards. We found a few maggots on some apparently healthy plants that had the cards. Thus the cards had not been a complete success, but they had saved more than we had expected from the conditions under which they were applied. The pest appeared in such mumbers as to severely test any method that might be devised to combat them. The soil was also very loose and uneven, and had been cultivated into ridges in which the plants had been set; and we purposely had the cards put on with only the care that an inexperienced person would take. Although the conditions were thus against the success of the method, yet Mr. Reeve reported in August that he had cut 327 heads from the two rows on which the cards were put; the west half of the 3rd row gave 77 heads, and the west half of the 7th row 60 heads (chickens had destroyed about 25 plants on the end of these half rows); from the east half of the first row he had cut 100 heads, and from the east half of the 4th row 90 heads. The two untreated rows together produced but 90 heads.

The experience of Mr. Smith given in his letter above, well illustrates the importance of proper conditions and proper care in applying the cards. He also writes us on this point: "If the soil is very light and loose, care must be taken that the plants are not pressed down too deeply so as to form a cup or dish around the plant. . . . If the land is very soft, the better plan would be to roll it before setting the plants." To further impress the idea of properly putting on the cards, we have introduced figure 16 which shows a card properly applied at *a*; and one carelessly put on at *b*, under which a female fly could easily crawl and lay her quota of eggs near the stem. With a little practice, the cards can be applied properly just as easily and as quickly as it can be done carelessly. Growers will soon learn, as have Messrs. Smith Brothers of Wisconsin, that the cards, to be effective, must be properly applied; and that when the cards are thus applied, they are very effective.

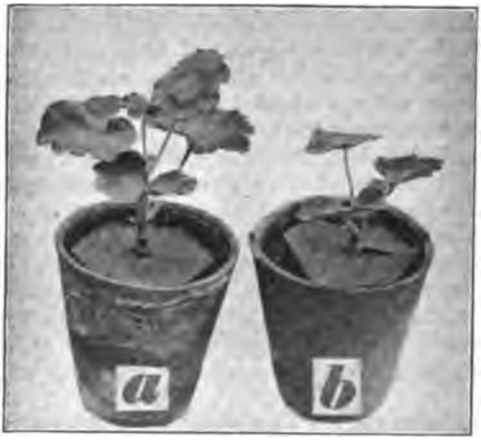

FIG. 16.—a, *Tarred Paper Card properly put on;* b, *a card carelessly applied that will not prevent.*

Our experience satisfies us that these cards will afford almost complete protection to cabbages and cauliflowers from the Cabbage Root Maggot, if a little care is taken in applying them. The protection evidently comes, not from the smell of the cards tending to drive away the fly, but from her inability to get to the stem to lay her eggs. The experience of the Messrs. Smiths at Green Bay shows that the cards are practicable on a large scale. Messrs. Smith Brothers wrote us they cut 20,000 for use this year; it costs them for material and labor about $1 to protect 1,000 plants. No second treatment is required; sometimes a little care is necessary in hoeing, so as not to cover the cards with dirt. In our State it will not be necessary to use the cards after May 20. They will not last more than one season, but new ones can be made during the winter when other work is not so pressing. Most of the Long Island gardeners with whom we discussed the method were favorably impressed with it, but some of them set their plants so deeply that it would not be practicable to properly put on the cards. The plants are set so deeply that the bases of the first 2 or 3 leaves are below the surface. Of this method of setting, Prof. Bailey says (Bull. 37, p. 405, of the Cornell Agr. Expt. Station): "We find as a result of three years' investigation, that the depth at which strong and stocky cabbage plants are set does not influence the extent or weight of the crop."

Therefore, we believe that gardeners will find that this method, which is unfortunately only applicable to cabbages and cauliflowers, will prove, when properly carried out, the cheapest, most practicable, and most efficient method yet devised for preventing the ravages of the Cabbage Root Maggot. However, the same objection may be raised against it as would apply to any preventive method; that is, it must be kept up for several years as the experience of Messrs. Smith Brothers shows. Our discovery that the pest breeds freely on several common weeds offers a reasonable explanation why this is true. If all of the Cruciferous weeds in the neighborhood could be exterminated and none of its other cultivated food-plants be grown unprotected near by, then a few years of prevention with the cards would doubtless starve out the pest in that locality.

B. DESTRUCTIVE MEASURES.

1. DESTRUCTION OF THE EGGS.

In 1879, Mr. Philbrick recorded that "the only effectual remedy he ever heard of is rubbing, with the fingers, the stem of the cabbage every few days to destroy the eggs and young maggots." Mr. H. A. March writes in 1887 that "he watches the flies carefully in the spring, and after they have been at work 4 or 5 days, he hires women to go along and rake (with a tool made for the purpose) all the eggs into the middle of the row where they dry up or the maggots cannot get to food; if any maggots are found they are at once crushed. The eggs are readily seen with keen eyes. The field is gone over again in a week, with the result that less than 5 per cent. of the plants are lost." In commenting upon Mr. March's account, Mr. Henderson says (*Rural New Yorker* for 1887, p. 578): "In my opinion it is the only thing that can be done to save the crop when the maggots are present. We adopted the same plan several years ago and have been comparatively free since."

This evidence shows that the method is practicable and efficient. Our experience with the eggs, as mentioned in the discussion of the oviposition of the insect, indicated that the eggs failed to hatch when much disturbed. Either Mr. Philbrick's or Mr. March's method would be effectual, and the only expense is the labor. The practicability and effectiveness of the method should recommend it to all gardeners.

2. DESTRUCTION OF THE MAGGOTS.

(*a*) *By Hand-picking*.

As is indicated in the correspondence included in the discussion of the Tarred Paper Card Preventive, some gardeners resort to hand-picking of the maggots to save their crop. It must be a laborious method, but has the merit of being very effective. It would seem, at first thought, hardly profitable on a large scale, and yet when we realize that oftentimes it means a loss of the entire crop if the maggots are not removed, then the method becomes practicable. Mr. Fletcher found in 1887 that cabbage plants may even be taken up, the roots examined, perhaps washed in strong soap suds, replanted, and yet after 2 or 3 weeks show no differences from uninfested plants which had not been disturbed. Thus, hand-picking is sure to be effective, is always practicable on a small scale or with choice plants, and is practiced sometimes by extensive cabbage growers with profit.

(*b*). *By the Use of Insecticidal Substances.*

Carbolic Acid.

Since 1881, when Prof. Cook first tested this substance, it has been used with quite uniform success by other investigators; but all have considered that its effectiveness was due to its odor, which prevented the flies from ovipositing on the plants treated with it. Mr. Fletcher says: "It must, however, be remembered that it is a 'preventive' of attack, not a 'remedy' for application after the attack has begun. It is for keeping the flies from coming to lay their eggs. When used as a remedy to destroy them it would have to be of such a strength as would destroy the plants also." He then quotes from Prof. Hilgard to show that "a solution of carbolic acid, that would be instant death to an insect sprinkled with it, becomes inodorous and harmless when filtered through a few inches of soil." Our discussion of this substance as a preventive, on page 552, should be read in this connection, for it includes the results of the experiments which have been made with the acid.

While applying the substance in our experiments there recorded, we found that it quickly soaked into the ground, leaving but little odor after a few hours; and we thus expected but little result from its use. But the results recorded in the preventive discussion of this substance show that it was quite effective, but was not so effective as the Tarred Paper Cards; and yet the much stronger, but similar, odor of the cards was not what gave the protection, for wherever not properly applied the flies crawled under and accomplished their object. It is also a significant fact in this connection that, in all of the experiments by Mr. Fletcher and Prof. Cook, although the applications were doubtless begun before any eggs were laid, yet the applications were continued either until the plants were large enough to eat or until after the time for the maggots to appear. We are therefore inclined to believe that most of the good results heretofore gained by the use of this substance have been through its killing power, either on the egg or maggot, rather than from its having had any preventive effect on the flies.

The following laboratory experiments show that it has decided killing powers. May 25, 100 small maggots, brought from Long Island, were put at the base of each of two well-established cabbage plants. The next day, after the maggots had begun work on the plants, the earth was removed from about the base of the plants until some of the maggots were laid bare. Then around one plant was poured 4 oz of an emulsion (1 lb. soap, 1 gal water, and ½ gal. crude carbolic acid) diluted with 50 parts of water, or at the rate of a pint of acid to about 22 gals of water. Around the other plant was poured 4 oz. of the same emulsion diluted with 75 parts of water. May 30, this latter cage was superficially examined, with the result that 30 dead and 3 living maggots, and 14 puparia were found; many of the dead maggots were found underneath the bark of the root in their burrows, while nearly all the live maggots seen were on the lowest roots where perhaps the emulsion had not penetrated. The puparia were replaced. June 7, both cages were carefully examined. In the one examined May 30, 8 of the pupar a were still alive, but no live maggots were found. In the cage where the emulsion was applied in a 50 part dilution, many dead maggots, 12 dead and 12 apparently live puparia, were found; no live maggots remained. In similar cages which received no treatment from 71 to 95 puparia were found. The killing power of the emulsion was thus very evident, and the 75 part dilution seemed equally as effective as the 50 part. In fact, this emulsion gave the most promising results of anything we tried here in the insectary, except the bisulphide of carbon treatment described later. None of the plants showed any injury from the application The same amount of the emulsion was applied to other plants, about large enough to set in the field, but which had no insects on their roots; and no injury had resulted from the applications 20 days later.

Thus, our experience, both in the field and in the insectary, lead us to believe that in this emulsion we have one of the cheapest, most effective, and most practicable killing agents that has yet been suggested for combating these root maggots. The material can be easily and cheaply obtained, so that the principal expense is in its application. Always use the *crude* carbolic acid as it is much cheaper than the purified and is nearly, if not quite, as effective. It will probably be safer if used as an emulsion than if simply diluted with water. We would advise that it be made by the following formula: 1 lb. of hard soap or 1 qt. of soft soap dissolved in 1 gal. of boiling water, into which 1 pint of *crude* carbolic acid is then poured and the whole mass agitated into an emulsion, which will remain in this condition for a long time. In treating the plants, take one part of this standard emulsion and dilute it with 30 equal parts of water; it probably can be used stronger without injury to the plants. If the emulsion is cold and semi-solid use several parts of warm water at first. Begin the treatment early, a day or two after the plants are up, or in the case of cabbages and cauliflowers, the next day after they are set in the field, and repeat it once each week or ten days until about May 20 in our State. While we have little faith in the preventive effects of the early treatments, we do believe that the emulsion will then kill many of the eggs and recently hatched maggots. If it could be applied with some force through a syringe or force pump, it might not be necessary to go to this trouble of first removing some of the earth from about the plants. It must be remembered that its success will depend on the eggs or maggots being hit with it. None of the cabbages in our experiment were injured in the least by an application containing nearly twice as much of the acid, and there is but little danger of its injuring the tenderest foliage of radishes, turnips or onions ; if any injury manifests itself on these crops, dilute the emulsion with 40 or 50 or more parts of water, instead of 30. A Knapsack or a Wheelbarrow sprayer would prove a very useful instrument in applying the emulsion on a large scale.

Whoever has tried this emulsion thoroughly report success, and we believe it is the most successful and most practicable method of treating radishes, turnips, or onions, yet devised ; for plants of the cabbage tribe, other methods discussed further on will prove more effectual. We hope this emulsion may be given a fair trial by many gardeners and other investigators. In our experience, it is more effective than the kerosene emulsion and rivals the bisulphide of carbon treatment.

CARBON BISULPHIDE.

Prof. Cook was the first to experiment with this volatile substance on the root maggots. In 1880, he used it for this purpose "with the happiest results. A small hole was made in the earth near the main root of the plant, by the use of a walking stick, and about 15 cubic centimeters of the liquid poured in, and the hole quickly filled with earth, which was pressed down with the foot. In every case the insects were killed without injury to the plants " The next year, Prof. Cook found that its use was not practicable in radish beds owing to the great number of plants to be treated, thus requiring so much liquid as to make it an expensive treatment; he tried making a few applications at short distances apart in the bed, but not with satisfactory results. In 1884, some of Prof. Cook's correspondents reported that the substance sometimes injured the cabbage plants, and its efficiency varied with the nature of the soil. The same year, Mr. Goff "found that bisulphide of carbon applied to the soil about the roots of radishes, destroyed the maggots that had not yet entered the root, but it had no perceptible effect upon those within."

In 1886, Prof. Cook reported before the Ingham Horticultural Society that experiments at the College that year had showed conclusively that, if carefully applied and used in time, it was a specific against the maggots. Those who had reported that it would not do effective work in clay soil, or that it killed the plant, had, without doubt, deferred the application till the plants were beyond hope. A Mr. Lee, in the audience, said he had tried the liquid, and knew it would always work on clay or sand, and not hurt the plants. *He made a hole a little way from the plant.* We italicize this sentence, because it is the keynote of success with this substance. We believe that most of the reported injury to the plants has been due to the hole having been made close beside the plants so that the liquid itself reached the roots. The liquid would very quickly kill the root, but its vapor would do no harm. This point is more fully emphasized later on

The following year, however, Prof. Cook says he is persuaded, after a thorough trial, that this substance cannot be made practicable. Differences in soils, and seclusion of the maggots which bore quickly out of reach of the insecticide, make its use uncertain, and therefore unsatisfactory. In 1888, Mr. Hulst reported that the substance could not be used, for when it came in contact with the roots it always did them very great injury. In 1892, in response to an inquiry from Mr. Barnhardt, the U. S. Entomologist advised him to try the liquid. Although the application was made (June 15) after many of the maggots had changed to puparia, he reported very satisfactory results.

From the above brief resumé of the experiments thus far reported with this substance, we glean that the weight of evidence shows that it can usually be depended upon to kill the maggots. The only serious objections raised are that it sometimes seems not to work alike in all soils ; also, it may injure the plants ; and such large quantities would have to be used on radishes, onions, or turnips as to make it expensive and thus not practicable on these crops. The last objection is doubtless a valid one, unless the plants are of a choice or new variety. However, we believe, as did Prof. Cook and Mr. Lee in 1886, that when properly applied, it will prove very effective against the maggots on any soils without injuring the plants ; of course, it will work slower somewhat on the heavier soils, and the dose may have to be increased slightly on such soils.

A few preliminary experiments in cages here at the insectary with this substance showed that it killed, not only the maggots, but the puparia also. Scarcely a live insect could be found in the cages the next day after applying a teaspoonful of the liquid to each plant. Ten puparia were placed beneath the soil in each of two cages, and to one cage a teaspoonful of the liquid was applied and the other was left untreated. No flies ever emerged in the treated cage, while nearly every one of the puparia gave out a fly in the untreated cage. In no case did the plants show any signs of injury from the liquid. We always applied the liquid in a horizontal hole begin-about three or four inches from the plant and running down to a point a little below the roots.

But while our experiments demonstrated that the substance was sure death to the insects and did not injure the plants, we were convinced that to make the method practicable in the field, some method must be devised by which the liquid could be more quickly, safely and perhaps efficiently applied.

It seemed as though some instrument might be, or possibly had already been, devised by which the liquid could be thus applied. We were unable to find any record of such an instrument having been devised in this country. The "Pal-injecteur" used in France is also too extremely heavy and clumsy, and very expensive.

The instrument devised by Prof. Cook in 1884, for the underground application of kerosene emulsion, apparently could not be adapted for the use of the bisulphide of carbon. Mr. Barnard's "Nether-inserter," devised in 1883, facilitated the making of the hole, but not the application of the liquid. Thus no instrument seemed to have been devised by which the application of the liquid could be made practicable in cabbage or cauliflower fields.

The case was stated to Mr. McGowen, the inventor of the famous McGowen Spray Nozzle. After several experiments in trying to simplify the French instrument, the idea was abandoned. He then started out on a theory of his own, and finally devised an instrument which seems to "fill the bill" quite completely. In honor of the inventor, we shall call it "The McGowen Injector." In construction, it is very simple, as the sectional drawings in fig. 17 show; the description of the different parts, and how they work are given below.

Description of the McGowen Injector.—Figure 17, *B*, represents a sectional view of the instrument, about one-seventh natural size. It consists of a long piston, *p*, its upper portion working closely in a small cylinder; the middle portion passing through the long reservoir, *r*; and to the lower smaller portion which passes through that part of the instrument, *g*, which is forced into the ground, is attached the valves, *v*, working in a cylinder attached to the lower end of the reservoir. A handle is attached to the upper end of the piston, and the lower end is pointed and works closely in the lower small cylinder only at the point opposite *g*. The reservoir is filled through the opening at *e*, which is protected by a screw cap. In B, the instrument is ready for insertion in the soil. At A, is shown a section of the lower portion of the instrument, nearly one half natural size, and this view represents the position of the valves, *v*, when the instrument is being withdrawn from the soil. It operates very simply. When the piston is pulled up it is stopped at the proper point by the metal pin through the piston near *p*, in B. This brings the upper valve into the reservoir, *r*, and the liquid immediately fills the chamber between the two valves; this is the measuring chamber, and its size can be easily regulated to hold a teaspoonful, or more or less, by simply screwing the valves either way or by winding cloth around the piston between the valves. Before inserting in the soil, the piston is pushed down and is stopped by the lower valve striking against the bottom of its cylinder. The valves are then in the position shown in B. As the lower portion of this valve cylinder is cut out larger, the liquid escapes into this lower chamber, *l. c.*, and some runs down around the lower part of the piston but is prevented from escaping by the arrangement near the point, at *g*, by which the piston here fits very closely. The pulling up of the piston again, of course, lets the charge of liquid run out, and at the same time the measuring chamber is again filled, thus securing an automatic action. It was found necessary to have an opening in the lower chamber, *l. c.*, in order to allow air to take the place of the liquid so it could freely run into the soil. This opening, *o*, also supplies the measuring chamber with air which is drawn up into the reservoir and then displaces the liquid and allows it to freely enter the measuring chamber. All parts of the instrument are made of brass, except the small discs or leather in the valves, and the wooden handle on the piston; the reservoir may be made of tin. All parts must fit closely, for the liquid works through where water would not. The reservoir can be made larger or smaller, and the lower portion which is inserted in the ground can be made of any length to suit the depth to which it may sometimes be necessary to apply the liquid. On larger instruments a foot-rest could

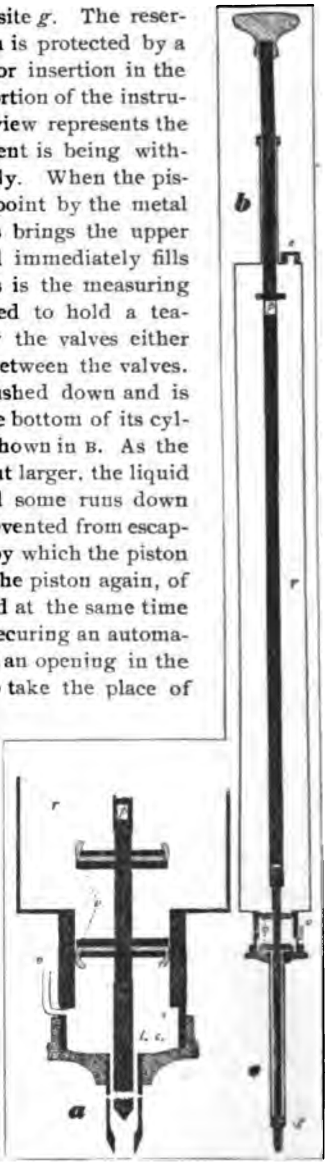

FIG. 17.—*The McGowen Injector.*

be easily attached to assist in inserting the instrument if necessary. The reservoir in our instrument (Fig. 18) is 2 feet long, 2½ inches in diameter, and holds 2 quarts of liquid.

All the parts of the injector are made of brass or tin except the simple discs of leather used in the valves, *v*. These can be easily replaced when worn. The price at which it can be made and sold will depend upon the demand and also on its size and the material of which the reservoir (*r*) is made, whether tin or brass. The reservoir in the one shown in operation in figure 18 is 2 feet long, 2½ inches in diameter, and holds about 2 quarts of the liquid. This is about the right size for use against the Cabbage Root Maggot, as one filling of the reservoir will treat about 500 plants, using a teaspoonful at each plant. It could easily be made larger without adding much weight to the instrument, for a slight increase in the diameter of the reservoir would greatly increase its capacity. Mr. McGowen can make them any size desired. The one shown in figure 18 can be made for from $3 to $5, depending on the demand for it and the material used; in large quantities, they could doubtless be made for less. The brass instrument we have has a capacity of 2 quarts and weighs when empty 4½ pounds, and when full of water 4 pounds more. Thus in gardens it will require but little more than the weight of the loaded instrument to force it into the soil. But if a larger instrument was needed it might be well to have a foot-rest attached near the bottom.

In fact, we believe the instrument can be so adapted as to work satisfactorily wherever the liquid is now used against underground insects. For instance, it will facilitate the application of the liquid to the new Grape Root-worm. (*Fidia viticida*) which has recently appeared in Ohio; and it is possible, as Prof Cook suggested in 1880, that the Peach Borer (*Sannina exitiosa*) may be killed by the substance, especially on small trees where it works almost entirely on the roots (we shall try some experiments in this line in the spring). Many other instances might be mentioned where it would be practicable to use the liquid, now that we have a suitable instrument to apply it. In fact, this simple and cheap injector should open up a whole field of experimentation with this liquid; why not use it against the root form of the Black Peach Aphis (discussed in Bulletin 49) or the Wooly Aphis of the apple.

The liquid is very volatile and will thus quickly evaporate if left in an open or uncorked vessel; we find large glass bottles with tight-fitting corks the best receptacles for it. The vapor is very poisonous and great care should be taken in pouring it out not to breathe much of it. As the vapor is also very explosive, no lights of any kind should be brought near when it is being used. Treat it with more care than you would gunpowder, in this respect. The best and cheapest brand now on the market is that known as "Fuma Carbon Bi-Sulphide," manufactured by Edward R. Taylor, Cleveland, Ohio. He ships it in 10 lb. cans at 12 cents per pound, or in 50 lb. cans at 10 cents per pound. It can be obtained in small quantities at drug stores, but usually for not less than 25 cents per pound.

Thus cabbage plants can be treated once, and once is usually sufficient, at the rate of about 10 plants for 1 cent for the liquid, using about 1 teaspoonful to each plant. As the injector will last for years, and several neighbors might join in the purchase and use of one instrument, its cost would practically not influence this estimate of the cost of killing the maggots. We believe it is the cheapest, most effective, and most practicable method yet devised for fighting this pest on crops of cabbages and cauliflowers; on crops of radishes, turnips, or onions it will probably be too expensive except where choice or new varieties are attacked. The Carbolic Acid Emulsion will prove the most practicable on these last crops.

The method of inserting the injector is shown in figure 18. The hole should always begin at a distance of 3 or 4 inches from the plant and run horizontally downward to a point a little below the roots. To accomplish this, the injector must be inserted at an angle as shown in the figure. Force it down until you think the point is a little below the roots, then let out the charge of liquid. In operating the injector, first pull the piston up as far as it will go; this loads the measuring chamber between the valves; then push down the piston until it stops, and the instrument is ready to be pushed into the ground. Push it into the ground as far as desired, hold it there while you pull up the piston; by this operation you let the charge out of the lower chamber into the ground, and at the same time the measuring chamber is again filled. Hold the injector in the ground a few seconds after the piston has been pulled up in order that all the liquid in the charge may have a chance to run out. Then pull the injector out of the ground, and quickly, with the foot, fill the hole with earth and step on it to pack it down. Press down the piston, and you are ready to treat the next plant. Never push the injector in the ground unless the piston is clear down, because if the lower end is not thus closed, it will immediately fill with soil which is not easily removed. Study the drawings in figure 17 in connection with these directions and you will understand the reason for each step. We would advise that the reservoir be first filled with water and the injector operated above the ground until each step is thoroughly understood. There is nothing complicated about the instrument, or the way it is to be operated. It can be easily taken apart and cleaned if necessary ; the only caution to be observed in replacing the parts is to have the flanges of the leather in the upper valve turned upward.

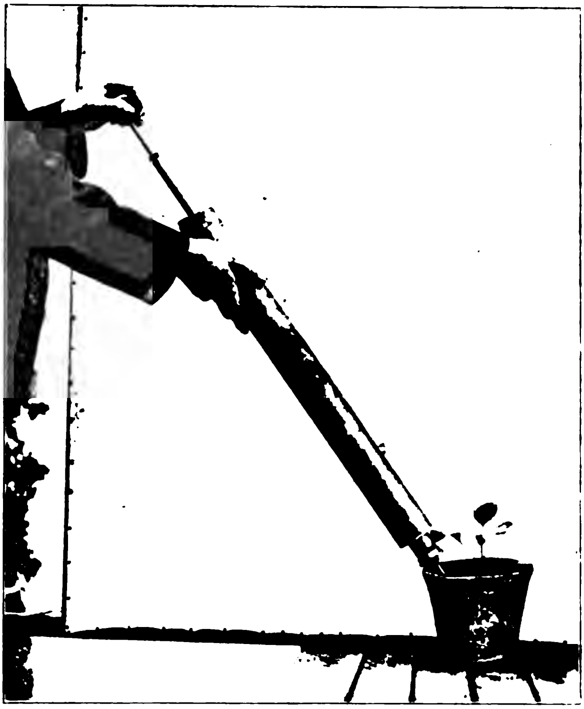

FIG. 18.—*The McGowen Injector, and how to use it.*

We recently tested the effect of the liquid on some young cabbage plants not yet large enough to set in the field. A tablespoonful of the liquid was applied beneath several plants with the injector. In a few minutes the odor of the liquid was very noticeable on the surface around the plants. These plants have not showed any signs of injury from this large dose. As stated in the description of figure 17, the amount of liquid to be applied can be easily regulated. On small plants, a teaspoonful will probably be sufficient. When the plants are well established in the field, and the maggots thick, use a tablespoonful. One application will usually suffice. The time to apply will be when the maggots are first discovered, early in May. Do not wait until the plants begin to wilt before making the application, for although it will then kill the insects, it will not reinvigorate the plant.

We believe gardeners will find this the most practicable and most effective method of killing the Cabbage Root Maggot when it attacks cabbages and cauliflowers.

2. DOUBTFUL, OR PARTIALLY EFFECTIVE METHODS.

With some gardeners, many of these methods may prove quite effective; in fact some have used them with apparent success. However, we believe that they should be more thoroughly tested before they are unqualifiedly recommended for indiscriminate use by gardeners.

A. PREVENTIVE.

1. Substances Applied to the Soil.

Gas Lime.

Doubtless the vile-smelling properties of this refuse from gas works, is what suggested its use as a preventive of the Cabbage Fly. However evidence accumulates every year that vile smells are not so obnoxious to insects as was thought several years ago. Prof. J. B. Smith showed (Bull. 75. N. J. Expt. Station, p.29) that gas-tar has no repellant effect on the Squash Borer. He also says (Bull. 85, p.8) that "it is important to know that what we consider as foul or vile smells never yet kept away insects. . . . It is not the smell of gas lime, but the caustic properties that are of value" Mr. Lazenby found (Mich. Hort. Soc. Report for 1881, p 213) that gas-lime did not effectively repel the Codlin Moth.

The first record we find of the use of gas lime to prevent this pest, is by Mr. Garfield in 1877. He treated alternate rows of radishes and turnips with the substance, "hoping by means of a vile odor to prevent the flies from laying their eggs." He reports it a failure. In England gas lime is extensively used by gardeners, and Miss Ormerod reports some favorable testimony for it as a preventive; none of the evidence is conclusive, however. In Canada, Mr. Fletcher reports good effects from putting a small quantity of fresh gas-lime around each Cabbage plant when setting it out; on radishes or onions it had to be applied at frequent intervals, and was then not an infallible remedy. Mr. Wright Rives, of Washington, D C., writes us that the cabbage growers near Beltsville, Md., use large quantities of gas lime yearly, and they report good results from it.

Thus, there is but little definite evidence either for or against the effectiveness of gas lime as a preventive. It cannot be readily obtained in many localities, and is liable to injure the plants if used when too fresh or in too large quantities. Wherever it is practicable it should be tried, although we are inclined to doubt its efficiency.

2. *Cultivation.*

Whatever method is employed in growing the crop seems to have but little preventive effect on the insect. It is true that often a much larger crop is produced in an infested field if the soil is kept well hilled up around the plant. In this case the difference is not due to the lessening of the numbers of the pest, but the plant, thus encouraged, sends out enough roots for both itself and the maggots. However, we believe that the numbers of the pest can be materially lessened for the next season by following the infested crop with some crop which the pest does not attack. This crop should be one requiring frequent cultivation so as to keep down all Cruciferous weeds, some of which we now know would harbor the pest. Also, if all the remnants of the crops upon which the pest feeds, as the cabbage "stumps," etc., are thoroughly removed and destroyed in the fall, we believe many of the insects will thus be destroyed. Thus, clean culture throughout the season will, we believe, materially lessen the numbers of the pest appearing next spring, and thus act as a preventive.

3. *Kerosene Oil and Sand.*

In 1885, Mr. Fletcher reported that he had good success in preventing the attacks of the pest on radishes by sprinkling sand saturated with kerosene (a large cupful to a pailful of dry sand) along the rows once a week until they were large enough to thin out and have the ground well hoed over the roots. He also reports good results from its application every week until the middle of July around the stems of cabbages. This simple method is practicable, on a small scale at least, and should be tried by gardeners, for all the evidence yet reported favors it.

B. DESTRUCTIVE.

I. DESTRUCTION OF THE MAGGOTS.

(*a*) *By the Application of Direct or Indirect Fertilizers.*

Lime and Liquid Manure.

The recommendation of this combination rests upon the experiment of Mr. Dunning in 1889. He found on May 20 that some early cauliflowers were badly infested by the maggots; the stems below ground were entirely encased in maggots. The next day he applied to each plant a pint of a mixture formed by slacking 5 pecks of fresh burned lime in 100 gals. of liquid manure; this was stirred ten minutes and poured around the plants with a sprinkler. From an examination of a dozen plants on May 27, he reports that not a live maggot could be found, and the plants had made a large amount of new roots. When he used gas lime instead of ordinary lime, the effect was not so good. He states that the lime water killed the maggots and the manure stimulated the roots. Where liquid manure can be obtained in such quantities, this combination should be tried. Judging from Mr. Dunning's report, this is one of the most promising recommendations yet made to combat the pest. We hope it may soon be further tested.

(*b*) *By the use of Insecticidal Substances.*

Hellebore.

In his report for 1890, Mr. Fletcher recorded the first experiments with this substance against the Cabbage Root Maggot. Some 3 years before he had learned that one of his correspondents had used a decoction of it with considerable success on the Onion Maggot. Mr. Fletcher applied the substance to about 1,200 plants in the following manner: "One person carried a 3-gallon pailfull of water in which 2 ounces of white hellebore had been steeped, and an ordinary green-house syringe, the other placing the left hand beneath the cabbage, palm downwards, with two fingers on each side of the stem, drew away the surface soil from the root of the cabbage, and at the same time, with the right hand, pulled the head a little over, so as to expose the roots. About half a teacupful of the liquid was then syringed forcibly around the roots, and the earth was quickly pushed up again around the stem. The result of this treatment was that only about one per cent. of the cabbages was lost. There is no doubt that the forcible syringing of the liquid removed the maggots to some distance from the roots; but by actual experiment it was found that the white hellebore killed them also." He records a further test of the decoction later in the season which resulted very satisfactorily, and from which it appeared that the hellebore killed by contact. He further says: "In applying this hellebore remedy care must be taken not to dig down too deep or disturb the root too much. The chief seat of injury is the underground portion of the stem above the mass of roots. If about two inches of the soil be removed that part of the stem most attacked is laid bare, but the roots need not be disturbed. An important thing is not to put off the treatment too long." In 1892, and in 1893, he reports this hellebore tea in a large measure successful, but concludes that it is practicable only in gardens and not for field practice.

Although others have since recommended this hellebore tea, yet no one except Prof. J. B. Smith seems to have tested it. In 1892, Prof. Smith had one of his correspondents test it on the cabbage maggots, using on each plant one-half pint of the tea, containing one ounce of hellebore in one gallon of water; it was reported a success. However, he says: "As against the Onion Maggot, I scarcely know whether to recommend it as yet, without further experiment."

May 25, we put 100 small maggots about the base of a well-established cabbage plant. The next day when the maggots had begun work on the root, we poured 4 ounces of hellebore tea (1 ounce steeped in 1 gallon of water) in a cavity about the plant. Four days later, we found live maggots working on the stem near the surface; and June 7, 68 live puparia (and one maggot still feeding on the stem) were found in the cage. As only 71 puparia were found in a similar cage not treated, it was evident that our application had had but little effect on the maggots. In another similar cage the decoction had no effect on mature maggots and recently formed puparia. The hellebore used was practically fresh, as it had been kept in air-tight jars.

In the face of such positive results attained by so careful an investigator as Mr. Fletcher, it would not be fair to conclude from our slight experience that this hellebore tea is not an effective killing agent when used againt these root maggots. And yet our experiment shows that there is need of further experimentation with the substance before it can be confidently recommended for indiscrimate use by gardeners. This simple remedial measure should be thoroughly tested by other investigators.

Kerosene Emulsion.

The first experiments we find recorded with a kerosene emulsion were made by Prof. Cook in 1884. He dissolved 1 qt. soft soap in 1 gal. hot water and then added 1 pint of kerosene oil. It was reported "a safe and very efficient specific against these very destructive maggots." He devised an instrument for applying it below the surface of the soil (Figured in Rept. Mich. Hort. Soc. for 1884, p. 204). Two years later, Prof. Cook treated radishes with a similar, but stronger, emulsion (1 lb. soap, 1 gal. water, 2 qts. kerosene) diluted with about 2 parts of water. Treatment was begun when the plants were small and continued every three or four days for 4 weeks; a tablespoonful was applied to each plant each time, and three-fourths of the plants were entirely free from the maggots. He concluded from his experiments thus far that, when made by the first formula, the emulsion was sure death to the maggots but must be applied early and often; he then preferred it to carbon bisulphide for he found it just as effective and in no danger of injuring the plants.

In 1884, however, Mr. Goff experimented with an emulsion made of 4 lbs. of soap, 1 gal. kerosene, and 1 gal. water. One ounce of this was dissolved in one pint of water and repeatedly applied to the roots of an infested cabbage plant, with apparently no effect on the maggots. The amount of kerosene used by Mr. Goff was greater than that used by Prof. Cook at each application.

In 1887, Prof. Cook applied his emulsion freely 3 times a week to cabbages and radishes; it seemed to have no effect on the insect, but in one case it injured the plants. He concludes: "that I have killed these maggots both in the garden and on potted plants in the laboratory, by the use of the kerosene and soap mixture. Yet upon a thorough trial I am persuaded that the remedy cannot be made practicable." Mr. H. A. March of Washington State wrote the same year that Cook's emulsion cost him 2000 cauliflower plants. In 1889, Mr. Hulst carried on some experiments with the Riley-Hubbard emulsion which indicated that when diluted with 9 parts of water it injured the plants, but could be safely used when diluted with 12 or 15 parts of water and it would then also destroy the maggots. There would be about as much kerosene in a pint of this dilution as Mr. Goff had used in his experiment. In 1889, Dr. Riley advised Zimmer Bros. of Alabama to try the emulsion on their cabbages then infested by the maggots. They reported that when diluted with 9 parts of water, it killed every plant; but when 12 parts of water were used in diluting, no harm resulted to the plants and the maggots were destroyed. In 1890, one of Prof. J. B. Smith's correspondents reported good results from the use of the emulsion diluted 15 times. Mr. Fletcher found the emulsion successful in 1892 and 1893; but says it is not practicable for field use. The Riley-Hubbard formula* for the emulsion has been used since 1888.

The evidence so far is quite conflicting. Evidently the emulsion is the most effective when made by the Riley-Hubbard formula; but unless each gallon is diluted with at least 12 gallons of water, the plants are injured.

May 23, we placed 100 small maggots on the base of a well established cabbage plant. The next day, after they had begun feeding on the root, 4 oz. of the emulsion diluted with 9 parts of water was poured in a cavity about the plant; and a similar amount of a 1 to 12 part dilution was similarly applied to another plant on which 100 small maggots had been placed. The next day a superficial examination showed that many of the maggots were dying. June 8, 32 live puparia were found in the cage where the 1 to 9 part dilution had been used; and 40 puparia in the other cage. As from 71 to 95 puparia were found in similar cages receiving no treatment, it is evident that the emulsion killed many of the maggots.

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*To make the Emulsion, thoroughly dissolve one-half pound hard or soft soap in one gallon boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force-pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This standard emulsion if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

The evidence would seem to support the conclusion that the kerosene emulsion (using 2 gallons kerosene, 1 gallon water, and one-half pound soap) diluted with 12 parts of water, will prove quite effective if applied early and often to radishes and onions, and two or three times on cabbages and cauliflowers. It must be applied thoroughly, by first removing some of the earth from around the base of the plant and either syringing in the liquid or applying through a knapsack sprayer. It will prove practicable on a small scale, at least. We believe, however, that the carbolic acid emulsion or the carbon bisulphide treatment previously discussed, will prove more effective and practicable.

2. DESTRUCTION OF THE PUPAE.

(a) *By Destroying old "Stumps" in the Fall.*

Some authors have recommended the removal and destruction of the old "stumps" usually left in the field in the fall, in order that the puparia which they may contain be thus destroyed. We doubt if there are ever many paparia in these old "stumps" in the fall, but some maggots may thus be destroyed. Doubtless more of the insects would be destroyed by the destruction of the "stumps" of the early crop as soon as the crop is gathered. In any case the old "stumps" should always be removed, for although they may not contain many specimens of this pest, they furnish breeding places and shelter for other noxious insects.

(b) *By Fall Plowing.*

Künstler, in 1871, suggested that many of the hibernating puparia might be destroyed by plowing the ground late in the fall. Messrs. Riley, Lintner and Fletcher have also recommended it. Doubtless a late plowing followed by a thorough harrowing would destroy or deeply bury some of the puparia and thus help to check the pest.

(c) *By Use of Gas Lime.*

Dr. Lintner, in 1885, suggested that a heavy dressing of gas lime applied in the fall, would doubtless kill many of the hibernating puparia. It might.

3. INEFFECTIVE, OR IMPRACTICABLE METHODS.

Under this heading are grouped those methods which have been thoroughly tested and found ineffective or impracticable; and some methods are also included which have not been sufficiently tested, but which we are inclined to believe will not prove effective or practicable. However, there are several methods in this latter group that should receive further investigation as is indicated in the conclusions drawn from the evidence submitted in the discussion of each.

A. PREVENTIVE.

1. BY ORDINARY FARM METHODS.

(a) *Selection of Soil.*

In 1886, the *Rural New-Yorker*, advised a correspondent to select a very sandy soil for a radish bed, to avoid injury from the maggot. The next year, in the same periodical, Mr. Goff gave similar advice. Yet Dr. Lintner said in 1882 that "the insect has been observed to be very injurious to earlier crops and upon *sandy* soil. It is thought that benefit has been derived from late sowing in *clayey* soil." We see no reason why the sandy soil would prevent or discourage the pest in any way. The soil in many parts of Long Island where the maggots work freely is quite sandy. The efficacy of the method is thus doubtful.

(b) *Time of Planting.*

Our discussion of the number of broods of this pest indicates that in some localities the first brood is not numerous enough to be noticeably destructive, while the second brood is often very destructive. This seems especially true in Canada. Hence, we find Mr. Fletcher and Mr. Fyles advising Canadian gardeners to sow radishes early, in May; but the former writer adds that this will not always prevent.

Farther south, in our State, all gardeners are aware that the pest is usually the most destructive to early crops. Hence, we find Cook in 1874, and Lintner in 1882, advising late sowing of radishes. In New York State, the pest rarely does much damage after July 1, so that gardeners find that late cabbages set at about this time escape with little injury from the maggots. In Canada also, Mr. Fletcher finds that cabbages set about July 15 are not troubled by the maggots. The application of the method then seems to depend upon the locality, as far as early crops are concerned, while late crops suffer but little in any locality. However, in many localities and especially on Long Island, it is the early crops that pay the best and are therefore the more largely grown; so that the time of planting is necessarily early, and the pest must thus be fought by other methods.

(c) *Trap Crops.*

In 1888, Prof. Cook concluded that the Cabbage Root Maggot relished radishes better tham cabbages, and he therefore suggested that the latter might be preseerved from attack by alternate rows of radishes. This, of course, implied that the radishes were to serve as a trap crop to entice the flies away from the cabbages, and later the radishes were to be destroyed with their accompanying maggots. Others, notably Mr. Hulst in 1888 and Mr. Fletcher in a recent letter to the writer, say that the pest is especially fond of cauliflowers, attacking them in preference to radishes or cabbages. No careful experiments have been recorded in this line. Cabbages or cauliflowers could not be profitably grown as trap crops. Radishes might in some cases, but the evidence is not conclusive that the pest would attack this crop in preference to either of the others.*

Therefore, in the light of our present knowledge of the preferences of this pest, gardeners cannot expect to save a crop of cabbages or cauliflowers by growing radishes between the rows. Thus, while this suggestion of the use of trap crops to combat this pest promises but little of practical value at present, it should receive further investigation, for it would be interesting, to know at least the preferences of the insect, if it has any.

(*d*) *Substances Applied to the Soil.*

Under this head come those substances which gardeners use, primarily to increase the fertility of the soil, but which some have thought also acted as preventives of the attacks of the maggot.

Lime.

This substance has doubtless been used to prevent the attacks of this pest for half a century. Almost everyone who has written of the insect during the past 40 years, has recommended lime as a preventive. And yet, the first reference we have found of its use (a Maryland correspondent to the "Country Gentleman" for 1857, p.47) gives negative results. In many accounts of the use of the substance, it is not clear whether it prevents the "Club-root" or its supposed cause, the maggot; thus this evidence is not of much value. This is especially true of the many accounts of its use by Peter Henderson. In fact, we have failed to find a single recommendation to use lime as a preventive of the Cabbage Fly, which is based on careful experiments from which definite conclusions could be drawn.

On the contrary, there are some quite definite accounts which show negative results from its use. Mr. West ("Country Gentleman" for 1880, p.470) applied, early in the spring, lime at the rate of 15 tons per acre to a small bed; this was dug in after a few weeks, and good cabbage plants then set. In spite of this he lost ⅓ of his crop from the maggots. Equally conclusive results were obtained in 1887 by Mr. Goff at Geneva, N. Y. He mixed "a quantity of air-slacked lime with the soil of two rows of a small plant of early cabbages at the time of setting the plants. As the season for the attack arrived it appeared that the plants of the plat were all suffering, and an examination made June 18, showed that twelve plants treated with the lime had sixty-six maggots, while eleven plants not treated had but twenty-four maggots, proving conclusively the ineffectiveness of the application."

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*Prof. Cook and others have recommended that if radishes were grown between rows of onions. the latter would be practically safe from the maggot. They probably would be safe from the Cabbage Root Maggot, but would they from the Onion Maggot? As we have shown on preceding pages, these insects are distinct species, and it is doubtful if the latter ever attacks radishes or the former, onions.

It thus seems to us from a critical survey of all the evidence we can find, that gardeners can not expect to *prevent* the attacks of the Cabbage Fly by the use of lime; its use as a destructive agent is discussed further on.

Salt.

Mr. Will (*Country Gentleman* for 1879, p. 167) and Mr. Hewes (ibid. for 1880, p. 39) claim to have had good results from the use of salt applied, in the hole in which the plant is to be set or on the surface around the newly set plant, to prevent the Cabbage Fly. Mr. West (ibid. for 1880, p. 470) used salt at the rate of three bushels per acre on a small bed at the time of setting the plants; he lost one-third of his crop. Doubtless the salt, thus applied, if it had any effect, would act by destroying the young maggots. Its destructive power is discussed farther on.

Salt and Lime.—A recommendation to mix salt and lime with the soil previous to sowing the seed or apply it to the surface after sowing, has found its way into the literature of root maggots. In 1843, Curtis quoted such a recommendation by a Mr. Sinclair, but it was to prevent the attacks of the Turnip Root Gall Weevil mentioned on a preceding page. As the separate use of these substances has not been attended with very favorable results as preventives, their combination would doubtless be no more effective.

Barn Manures.

So far as we know, stable manure has never been recommended as a preventive of this pest, but as it is one of the substances frequently applied to the soil by farmers, and as it doubtless affects the insect in a certain way, it seems best to discuss it in this connection.

When Bouché described the Cabbage Fly in 1833, he said that the avoiding of the use of new dung was of no avail; and this statement has been emphasized by almost every writer since. In fact, many prominent writers, including Curtis, Miss Ormerod, Lintner, Fletcher, and Henderson, all conclude that fresh manure attracts the flies and thus encourages, rather than prevents the attacks of the pest. This idea is well supported by several experiments recorded by gardeners. Thus, the use of fresh barn manures are to be avoided on crops attacked by root maggots; even where well-rotted manure is used the maggots seem to be more numerous. This is doubtless one reason why the commercial fertilizers are now largely used by gardeners. The probable reasons why the barn manures attract the pest are discussed on a preceding page under the food-plants of the insect.

Commercial Fertilizers.

Ashes.—In 1857, unleached ashes were used in Maryland without success (*Country Gentleman*, p. 319). Mr. Goff reported in 1885 that two years before in the spring, he forked in a very liberal dressing of coal ashes before sowing radish seed. "The roots produced were nearly or quite as badly infested with the maggot as others grown without an application of ashes." Thus there is no evidence that ashes will prevent injury from maggots.

Bone Dust—This substance has been recommended by various writers since Henderson recorded ("Gardening for Profit") an experiment which simply indicated that fewer plants were injured where a ton of this was used per acre in the spring, than where 75 tons of manure were applied. However, in 1864, a German experimenter found that his bed of Kohlrabi which had been manured with bone dust suffered more from the maggots than the one on which horse dung had been used.* In 1875 (*Country Gentleman*, p. 505) Mr. Philbrick said bone dust does not give the results given by Henderson. Mr. West (*Country Gentleman* for 1880, p. 470) also used it at the rate of a ton per acre, and yet lost one-third of his crop of cabbages. Thus the weight of evidence is against the efficacy of bone dust as a preventive.

Cotton Seed Meal.—In 1887 (*Rural New Yorker*, p. 133), Mr. Henderson records an experiment by Mr. Geraty of South Carolina who claimed to have secured entire exemption from the maggots by the use of this substance as a fertilizer. We have found no further reference to it. It might be well to test it in localities where it can be profitably used as a fertilizer.

Superphosphate of Lime.—In 1857, this fertilizer was reported as a successful preventive of the Cabbage Root Maggot ("*Country Gentleman*" p. 49). In 1864 the substance was used in the noted German experiment mentioned above in the discussion of Bone Dust; in the bed manured with this fertilizer, no plants were attacked. This experiment is the source of most of the recommendations of this fertilizer. In 1877, Garfield of Michigan reported that he treated alternate rows of turnips and radishes with it, hoping that its vile smell would prevent egg-laying; it proved a failure. If it has any preventive qualities, which we doubt, it should receive the immediate attention of some investigator.

(*e*) *Change of Location, or Rotation of Crops.*

Many writers have advised that the location of the crop be changed every year or two, thus keeping it out of the way of the insect. But, as Prof. Cook says, it would be necessary to move it at least ½ a mile away, which is not often practicable. When it can be done, doubtless good results will often follow. However, some gardeners have found that even when the crop is grown on new ground, where perhaps a similar crop has never been grown, that the crop is sometimes badly infested. In this case, perhaps some of the flies from an old bed found their way to the new, but the more probable explanation, we believe, is to be found in our discovery that the pest breeds freely on at least two very common Cruciferous weeds, which would thus afford a source of infection. So that a sufficient change in the location of the crop is not often practicable, and will often prove unsuccessful if Cruciferous weeds abound in the new field.

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* This experiment is referred to by Dr. Lintner and Miss Ormerod as having been made by the Zoölog-Botan. Society of Vienna, which, if true, would give it great weight. But the facts are that it was simply recorded in the proceedings of that society for 1864 by Mr. Künstler to whom it was reported by Baron Hohenbruck. The experiment was evidently on a small scale, and Mr. Künstler concludes as follows: "It does not occur to me to wish to deduce, from this single result, the value of any of the named manures in view of an eventual efficiency against the attacks of the insects; I present this case only to urge the farmers to make observations in this direction with manure experiments. . . . An effective and practicably applicable means of lessening this pest, no one as yet knows." The species experimented upon was determined by Frauenfeld and Schiner, from the pupae, as *Anthomyia radicum*.

A judicious rotation of crops can not help but discourage this pest, and thus gardeners may be able to grow a good crop of one or more of its food-plants once in perhaps two or three years. But the market wants these crops every year, and it will thus require considerable experience to know what crops can be thus successfully rotated and all be made to pay well. Of course, the rotating crops must be widely different botanically so as not to offer any chance for the insect to continue breeding in the locality, and no Cruciferous weeds must be allowed to grow in the neighborhood, for the insect could breed on these until its favorite food-crop came around in the rotation. On the whole, therefore, while both a sufficient change of location of the crop and a judicious system of rotation of different crops each year will prove quite effective in preventing the ravages of the pest, we fear that few gardeners will find either method practicable or uniformly successful.

2. BY APPLICATIONS TO THE ROOTS BEFORE SETTING.

This is one of the earliest methods employed in combating these maggots, and is only applicable to plants of the cabbage tribe. It consists in dipping the roots and base of the young plants in a puddle of some fertilizing or insecticidal substance when the plant is being set.

(a) *Fertilizing Substances.*

Puddle of Earth and Cow Dung, or Night Soil.

In her report for 1881, Miss Ormerod said: "Dipping the plants in a puddle of earth, and cow-dung, or night soil, taking care to smear the roots and stems well up to the leaves with the mixture, is noted as a good preventive." This has been quoted by several American writers. This puddle would seem to offer no obstacles to the flies, in fact, it would attract them, if anything, and if the pest was at all numerous it would not save the plant. For its only effect would be to furnish the plant quickly available food at the start which would push it along, and in this way enough roots might be produced to support several maggots and the plant also. The method would require considerable disagreeable labor, and we believe would have no effect in lessening the number of the maggots.

Soot, and Lime and Soot.

In 1883, one of Miss Omerod's correspondents found that the dipping of the roots in a thick puddle of soot and water was quite effective. He thought the soot gave the plant a bitterness which warded off the maggots. Gardeners could easily try it on a few plants, but we doubt its having any preventive value.

Lime and Soot.—We find a puddle of lime and soot advised in Miss Ormerod's "Manual of Injurious Insects," and by "Horticola" in the "Rural New Yorker" for 1881. There are no definite records of its value. The lime would have little or no preventive effect, and there is but little evidence in favor of the soot as shown above.

(*b*) *Insecticides.*

Oil or Lye.

Several American writers, including Lintner, Riley, Saunders, and Fyles, have included in their remedies for this pest the recommendation to dip the roots in either oil or lye before setting. This seemed to us a very harsh treatment for the tender rootlets of seedlings, and we were thus led to wonder how the recommendation crept into the literature to be handed down to the present time. The two first named authors attributed it to Bouché. Turning to Bouché's earlier accounts in 1833, we find, following Loudon's literal translation of Kollar in 1840: "Dipping the plants to be transplanted in oil or lye of ashes, or soaking the holes that are to receive them with these liquids, will often destroy the plants, and cannot therefore be recommended." How could a positive recommendation be evolved from that? A search through the literature soon revealed who evolved it. Turning to Curtis' account of the insect in 1843, we find this: "It often happens that very good specifics which may be successfully employed in the garden cannot conveniently be extended to the field; such, I fear, is the following remedy proposed by Bouché. He says that where whole fields of cabbages have fallen a sacrifice to the destructive maggots, that the crops are now completely preserved by dipping the roots, as they are transplanted, into oil or lye of ashes." It is unfortunate that our American writers have depended so much on Curtis' account of this pest, both from a systematic and economic standpoint.

Pyrethrum.

In this report for 1885, Mr. Fletcher says: "In my own experience the most satisfactory preventive treatment has been to dip each plant bodily into a pail of pyrethrum wash (containing a little soap) at the time of planting out." In addition to this he uses fresh gas lime around each plant to prevent eggs from being laid. It is doubtful if the pyrethrum has any preventive effect used in this manner; whatever protection is offered, is doubtless due more to the gas lime.

Paris Green and Insect Powder.

In 1886, a Massachusetts correspondent ("Rural New Yorker," p. 840) tried to save his cabbage and cauliflower plants by dipping them before setting in a puddle of dirt and water to which a quantity of insect powder (pyrethrum ?) and Paris Green was added. The plants soon dwindled and died from the treatment.

Sulphur.

A Washington State correspondent, Mr. H. A. March ("Rural New Yorker," p.678) in 1889 records an experiment in which he saved many plants by dipping them in a puddle of ½ pound of sulphur and water. However, no definite conclusions can be drawn from the puddling, for matters were complicated by the further application of ½ teaspoonful of dry sulphur on the soil around each plant after setting. The evidence warrants a further trial of sulphur either as a puddle, or applied on the surface.

Soap and Quassia, or Carbolic Acid and Soap.

Mr. Whitehead, of England, in his report for 1892 advises that plants be dipped in "solutions of soft soap and quassia, composed of 7 lbs soap, 12 lbs. of quassia, to 100 gals. of water; or of 7 lbs. of soft soap and 6 or 7 qts. of carbolic acid." No evidence is given in support of either recommendation and the effectiveness of the first is very doubtful, while the second would be liable to injure the plants.

3. APPLICATION ON OR ABOUT THE PLANTS.

(*a*) *Coal Dust, or Sulphur.*

Coal Dust.—All the recommendations of this substance as a preventive are based on an experiment made in Russia in 1855 (Bull. d. l. soc. imp. des natural, de Moscou., XXVIII). Through Taschenberg's account of this experiment, it has clung to the literature to the present time. The experiment indicated that the flies avoided those plants about which coal dust has been scattered. But, as Taschenberg observes, it is necessary to the success of the experiment, that some plants be left untreated as baits to entice the flies to oviposit on them; these baits are afterwards to be destroyed with their accompanying maggots. When no plants are left for baits, Taschenberg says the flies then accommodate themselves to the beds entirely covered with the coal dust. It is curious that so simple a preventive seems not to have been tried since this first experiment. We have but little faith in its effectiveness, but it should receive a trial wherever practicable.

Sulphur.—All the evidence in regard to the use of this substance as a preventive seems to come from Mr. H. A. March, of Washington State. His method of using the substance has been stated above in discussing the puddling of the roots in sulphur. Mr. Crozier ("The Cauliflower," p.98) quotes Mr. March as follows: "The best thing I have found for the maggot is a *poor* grade of sulphur, sulphur before being purified, that *smells very strong*. Sprinkled over the plants it seems to drive the fly away." The substance is evidently worthy of a further trial.

(b) *Insecticides.*

Powdered Tobacco, and Tobacco Decoction.

In 1857 ("*Country Gentleman*," p. 319) E. Saunders reported that an Albany gardener had saved his plants by sifting powdered tobacco on them, enough to lay a fine dust on the leaves, and repeating the application if it was scattered by wind or rain. It was stated that the fly would not alight upon the dusted plants to deposit its eggs. In 1877, Mr. Garfield, of Michigan, used a strong decoction of tobacco on cabbage while yet in the seed bed and after transplanting in the field, but it did not prevent the fly from laying her eggs. In 1885, Mr. Goff had no success in preventing the attacks of the maggots on radishes by the use of liberal dressings of finely-cut tobacco leaves. However, the application was made rather late, for many of the eggs may have already hatched and the maggots have begun work; so the experiment is not conclusive.

In planning the preventive experiments to be tried on our plot on Long Island this year, it was decided to test tobacco dust; for it has the merits of cheapness (costing from 1 to 3 cents per pound), it is easily applied, has fertilizing qualities, and its use would thus be practicable. On April 18 the cabbages were set in six rows, running east and west, of about 300 plants each. The plot was divided into practically equal parts by a north and south division line. The following diagram represents the plan of the preventive experiments; the treated rows being represented by the name of the preventive used on each, and the word "untreated" represents the other rows:

NORTH.

WEST.

1st row:	Tobacco Dust	Paper Pads
2nd row:	untreated	untreated
3rd row:	Paper Pads	Carbolic Acid Emulsion
4th row:	untreated	untreated
5th row:	Carbolic Acid Emulsion	Paper Pads
6th row:	Paper Pads	Tobacco Dust

EAST.

SOUTH.

Thus two whole rows were to be left untreated as checks, and tobacco dust used on two widely separated half-rows.

April 19, the day after the plants were set, we applied the dust. All the dust that could be grasped in one hand sufficed for three plants, thoroughly dusting each plant and covering the ground close to the stem; at this rate, 7 lbs. of the dust treated about 300 plants once. April 30, a second similar application was made by Mr. Reeve at our request. At that time he reported that the plants were all looking healthy and showed no differences; he noted a good many flies about the plants. May 15, we had Mr. Reeve treat the west half of the first row with the dust a third time, to thus test the effect of two and three treatments. May 21, we examined the plot and found that chickens had destroyed about 25 plants on the west end of each row; however, this interfered but little with the general results of the preventive treatments which were then quite noticeable. The maggots were then at their worst, and there were scarcely 50 plants in either of the untreated rows that had not wilted. While about ½ of those treated with tobacco dust had succumbed, with no difference noticeable in those treated two and those treated three times. In August, Mr. Reeve reported that 35 heads were cut from the west half of the first row and 75 heads from the east half of the sixth row. Thus nearly half of the plants treated with the dust produced salable heads; while from the untreated rows Mr. Reeve reported only 90 heads from nearly 600 plants set.

Plants can be treated once with this tobacco dust at a cost of not over one cent for ten plants, and the experiment indicates that it affords some protection, but there were other untreated plants to act as baits. And an examination May 21 of many of the treated plants that were apparently healthy, showed that several maggots were at work on many of them. Therefore, we are not sufficiently convinced of its effectiveness to feel warranted in advising its general use as a preventive against the maggots.

Carbolic Acid, diluted, emulsified, or combined with Plaster.

Carbolic Acid, diluted.—In 1886, Mr. Goff reported the following results with this substance: "On May 2, we applied this solution at the rate of 3 grammes of the acid, to 5 gallons of water, to the soil about the roots of a row of radishes in the garden. On May 11, we renewed the application, doubling the amount of the acid. May 18, we repeated it, using 8 grammes of the acid to 5 gallons of water, following with the last named solution on May 23. No benefit resulted from these applications that we were able to detect. It is possible that the plants would have borne a still stronger solution, which might have been efficacious." We believe it would have been effective if used stronger, but it is our experience that it is just as effective, perhaps more so, and not so liable to injure the plants if applied in the form of an emulsion.

Carbolic Acid Emulsion.—This preventive was first suggested by Prof. Cook in 1881. He then made an emulsion by dissolving 2 qts. of soft soap in 2 gals. of water, and then adding 1 pint of *crude* carbolic acid, thoroughly agitating the mixture which soon formed a stable emulsion. To every pint of this standard emulsion he used 50 pints of water to dilute it before applying; thus the acid was used on the plants at the rate of a pint to about 125 gals. of water. He got excellent results by sprinkling the radish plants as soon as they were up, and thereafter every week or ten days. In 1886, Prof. Cook again experimented with this emulsion, but made it with 1 lb. soap, 1 gal. water, and ½ gal. crude carbolic acid; diluted with 75 parts of water. The acid was thus used at the rate of about 1 pint to 28 gallons of water, or over 4 times as strong as he used it in 1881. This was applied to cabbages, a tablespoonful to each plant, at intervals of from 4 to 7 days for 3 weeks, with the result that only 5 out of 21 treated plants were injured by the maggots, while 16 out of 24 untreated ones were attacked; the plants were uninjured. He also used the same strength of emulsion on radishes, a teaspoonful to each plant, with the result that 5 out of 18 treated plants were found infested, while 22 out of 32 untreated ones were badly injured; all of the plants, however, were injured by the liquid. Prof. Cook seems not to have tried the emulsion again. Had he made it according to his first formula and used it more freely, we believe he would have had greater success in 1886.

For, this is the experience of others who have tried the emulsion. During the summer of 1887, Mr. Fletcher used Prof. Cook's first formula, diluting it 50 times, on radishes. He began 2 days after the seed was sown and treated the bed, using an ordinary sprinkler, once a week until the radishes were fit for the table. He grew radishes in this way all summer free from attack, with no injury to the tenderest foliage nor was any offensive taste given to the vegetable.

This emulsion was selected as one of the preventives to be used on the cabbages in our experiment on Long Island. Our emulsion was made by dissolving 1 lb. of soap in ½ gal. of water and emulsifying this with 1 pint of crude carbolic acid. Each cupful of this was diluted with 50 cupfuls of water before applying; thus about 38 gallons of the dilution would contain 1 pint of the acid, or the emulsion was used about 3 times as strong as Prof. Cook first used it. Our experiment was planned as described in the diagram on page 551. Two half rows were treated with the emulsion, or about 300 plants in all. About ½ teacupful of the dilution was poured in a solid stream from an ordinary sprinkler around the base of each plant. The first application was made April 19, the day after the plants were set. A second application was made by Mr. Reeve on April 30. On May 21, when we examined the plants, the maggots had done their worst, and in the untreated rows there were scarcely 50 plants yet standing in either row. While about ¾ of those treated with the emulsion were in good condition and but few of them had any maggots at the roots. In August, Mr. Reeve reported that he had cut 90 heads from the west half of the fifth row and 85 heads from the east half of the third row; while from the untreated rows he got only 90 heads from the 600 plants set. Thus the results were quite encouraging.

However, we doubt if the emulsion applied early in the season, acts to prevent the flies from laying their eggs. Our experiments, recorded on page 529, indicate that it is a powerful killing agent, and there is yet no definite evidence that smells of any kind will keep the flies away. The discussion of the emulsion as a killing agent on page 529 should be read in connection with this account.

Carbolic Acid and Plaster.—In 1888, Prof. Cook mixed the *crude* acid with plaster (1 pint to 100 pounds of plaster), and applied it around the stem of cabbage plants. "None of the cabbages were attacked, but the slaking or setting of the plaster about the plants was a serious injury to some of the plants." Therefore, he could not advise its use for this purpose.

B. DESTRUCTIVE.

1. DESTRUCTION OF THE MAGGOTS.

(*a*) *By Destroying Infested Plants.*

In 1833, Bouché concluded that the only way to diminish this destructive fly is to pull up and destroy the infected plants with their accompanying maggots. Many later writers have included this method among their remedies for the pest. Of course, there can be no question of its effectiveness in checking the insect, but every plant thus destroyed represents considerable labor to the gardener, besides the reduction it makes in the profits when the crop matures. We believe there is no occasion for the practice of the method. The maggots may be killed in several ways, as has been shown, without injury to the plant.

(*b*) *By the Application of Direct or Indirect Fertilizers.*

Ammonial Liquor.

This refuse liquor from gas works was used by one of Miss Ormerod's correspondents in England in 1881. It was diluted with about twice the quantity of water, and one pint of the dilution was applied around the stems of each plant. Three or four such doses saved only the plants that were not too far gone when the treatment was first applied. We doubt if the liquor would kill the maggots; it would probably simply encourage or stimulate the plants to send out enough roots to support itself and the maggots also.

Soot.

Last year, at the Pennsylvania Experiment Station, soot was sprinkled about some cabbages which were found infected by the maggots. It seemed to save a few plants. No definite opinion can be formed from this single experiment. Wherever soot is plentiful, its destructive powers should be further tested.

Ashes.

In 1861, Mr. Gregory advised that ashes be used around the plants to destroy the maggots. Mr. G. H. Howard, in 1888, said that a small handful of wood ashes put down around each stem is a sure remedy if applied in time, that is, before the maggots have destroyed the bark and roots of the plants. However, Prof. Cook, in 1886, used unleached ashes against the maggots with no success.' When sprinkled on the foliage the plants were seriously injured. Last year, Washburn in Oregon, had fairly good results, but the ashes had to be applied frequently. Possibly enough ashes could be applied to the maggots to kill them, but the amount that could be safely applied to the plants doubtless acts simply as a fertilizer thus enabling the plant to make roots enough for itself and the maggots. Mr. Howard evidently implied this when he stipulates that the bark and roots must be intact or the ashes are not effective. Thus, we do not believe ashes can be relied upon to destroy the maggots.

Nitrate of Soda.

In 1881, a correspondent reported to Miss Ormerod that an application of a solution of this substance saved only a few plants. Mr. Fletcher reported in 1887 an experiment by one of his correspondents which indicated that the substance might act remedially. In 1891, Prof. J. B. Smith recorded his belief that this fertilizer would do much to control the injury from the maggots, but it should never be applied close to the plants, but broadcasted.

Thus there is no experimental evidence from which can be drawn definite conclusions in regard to the action of this fertilizer on the maggots. However, as Mr. Whitehead said in 1892, it has been found valuable, for if it fails to act remedially, it at least stimulates the plant's growth and thus helps it along out of the way of the maggots. As a killing agent against the maggots, we believe it has no value unless used so strong as to kill the plant also.

Muriate or Sulphate of Potash.

In 1887, the editor of "The Rural New Yorker" suggested that Mr. Henderson try the muriate on the maggots. In 1888, Mr. G. H. Howard advised that to each plant be applied a gill of a solution made by putting one spoonful of the muriate in a quart of water. However, he made the same proviso as to its effectiveness as mentioned above in discussing ashes. In a pamphlet on the "Cauliflower," Mr. Brill says (as quoted from Crozier on "The Cauliflower") that the muriate is a remedy for the maggots. He dissolved 1 tablespoonful in a gallon of water and applied one gill of this to the roots of each plant, repeating the application as occasion required. He well says: "Care and judgment must be used not to overdo the matter, thereby killing the plant as well as the maggots. Experiment a little at first." Mr. Brill wrote us in August as follows: "While my experiments with the Muriate of Potash to kill the root maggot was in the first instance a success, yet it does not always have the desired effect. I presume much depends upon the conditions of the worms and the plant when applied." Thus there is nothing definite in the evidence either for or against the effectiveness of the muriate on the maggots. We have no faith in the killing or preventive properties of either the muriate or the sulphate of potash unless used so strong as to injure the plant also.

Kainit.

This fertilizer was first used against the root maggots at least 7 or 8 years ago. One of its first advocates was Mr. Brill; his pamphlet on the "Cauliflower" is doubtless the source of the few recommendations which the substance received until within about 4 years. In 1890, Prof. J. B. Smith had his attention turned to kainit as a possible insecticide, and he performed the following experiment with it on the pest under discussion: "A number of cabbage maggots placed on the soil (in a tin can) impregnated with the solution. died within 12 hours." (These were very unnatural conditions.) No further experiments seem to have since been carried on with this substance against the Cabbage Root Maggot.

Last year Prof. Smith had some of his correspondents experiment with kainit on the Onion Maggot (An. Rept. for 1893. p. 441). He says: "The entire fields were gone over, row by row, and all plants that showed signs of infection were taken out bodily and afterwards destroyed. Then heavy dressings of kainit were applied, with the result that no further traces of these maggots were seen at any time later in the season." This year he reports similar results from a similar use of kainit in the same locality (*Insect Life*, vii, 196). It is to be regretted that Prof. Smith could not have made these experiments more conclusive by his personal supervision. The destruction of all of the plants that showed any signs of infection *before* the kainit was applied, prevents very definite conclusions from being drawn as to the destructiveness of the kainit. In his report for 1893, p. 441, Prof. Smith mentions that some experiments were made on a fly larva which was at first mistaken for the Onion Maggot. He writes us that "this Ortalid larva was remarkably resistant to almost anything that I could use, except the kerosene"; recently (*Insect Life*, vi. p. 96) he intimated that kainit was one of the substances used on these maggots which were found in diseased onions and which are so closely allied to the Onion Maggot as to have been mistaken for it.

It is also worthy of note in this connection that in one of the first references we find to the use of kainit against this pest (*Rural New Yorker* for 1887, p. 238), a Georgian contributor says it must be put on in time to kill the eggs, for it will have no effect on the maggots after they hatch. From the above evidence, we do not feel warranted in recommending that gardeners may expect to kill the root maggots by an application of kainit that would not at the same time kill the plant.

We are supported in this opinion by the following experiments, conducted on maggots brought here from Long Island. Several thrifty cabbage plants were potted out, and on May 23 some of the soil was removed from around the base of the plants and 100 maggots, none of them over ⅔ grown, were placed close to the base and covered with earth. They were left undisturbed until the next day when it was found they had established themselves on the plants. May 24, the soil was removed until at least 25 of the maggots were laid bare. Then 4 ounces of a solution of kainit (½ lb. to a gallon of water) was poured around the stem; in one case 20 of the maggots floated about in the solution for over a minute. Another similar cage with 100 small maggots was started May 25, and the same amount of kainit applied on the 26th. One of the cages was examined May 25, and the notes say: "No indications that even the smallest maggots have been killed." By June 6, when all of the cages were carefully examined, most of the maggots had changed to pupae. In the cage where the maggots were mentioned as floating in the kainit solution, 83 live pupae were found; in the other two treated cages there were 50 and 63 live pupae, respectively. An examination of two check cages started at the same time in a similar manner with 100 small maggots, but not treated with kainit, revealed 95 live pupae in one and 71 in the other. If the kainit used at the rate of ½ lb. to 1 gallon of water is not more effective on the maggots under these somewhat confined conditions than these results show, one surely could not advise gardeners to use it with the expectation of killing the maggots.

To test astronger solution, we started two similar cages of 100 small maggots on May 24. May 25, 4 ounces of a solution of the kainit (1 lb. to 1 gal.)

was poured into a cavity about the base of the plant as in the experiments above; in one cage nearly ½ of the maggots were near the surface and thus got a thorough soaking. In 2 or 3 days a superficial examination showed that a few maggots had been killed, and many had not, but both plants were considerably injured by the solution. To further test the effect of this strong solution on the plant, it was applied to plants having no maggots on their roots. June 6 all of the cages were carefully examined. Sixty-four live pupae, many of them recently formed, were found in one and 50 in the other cage. The plants were all badly injured by the solution. The same check cages were used as in the preceding experiments.

We do not offer these experiments as conclusive evidence that kainit will not always kill the Cabbage Root Maggot. But the results do show that it will not always kill the majority of the maggots even when used strong enough to badly injure the plants. Thus, from the evidence submitted, we cannot escape the general conclusion that it would be well to first definitely settle, by careful experiments, whether kainit will kill a majority of the maggots when used in practicable amounts, before we recommend it to gardeners for this purpose.*

Salt.

The first record we find of the use of salt as a destructive agent against root maggots is in 1877, when Mr. Garfield of Michigan partially removed the soil from the roots of infested cabbages, then salt was thrown in and covered up; "it soon dissolved, but to no purpose." In 1881, Miss Ormerod reports that a solution of salt saved but a few plants. A solution of salt at the rate of 4 oz. to one gallon was tested by Mr. Goff in 1889; "it produced no visible effect." Mr. Fletcher recently reported conflicting results from its use against the maggots.

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* Although we do thus doubt the insecticidal qualities of kainit when used against the root maggots in practicable quantities, we do not wish to discourage its use by gardeners for fertilizing purposes. And yet, as Mr. Wright Rives, of Washington, D. C., has so tersely expressed it in a recent letter to us, "I want potash, not salt; therefore I do not use kainit." In some cases these commercial fertilizers may furnish to the plants, just at the right time, the food needed to enable them to outgrow the injury caused by the insect. But, the insect still remains a constant menace to the gardener. Mr. Fletcher showed in 1890 that "the power of the cabbage plant to survive and outgrow injury is very remarkable. Several plants of which the roots and nearly all the underground stems had been destroyed, were washed and trimmed, and then planted and watered, and the earth kept well hoed up around them. Every one of these grew and produced a head. In years of only light attack it is not at all uncommon to find when cabbages are pulled up, that they had been supported by roots which were produced some distance above the root-mass, which had been destroyed early in the season by the cabbage maggot." There are several accounts of the use of commercial fertilizers on plants infested with the root maggots, but with no claim of having saved the crop by the maggots having been thus destroyed. As Peter Henderson expressed it when he used guano and lime: Strong roots were made above the wounds, and thus the crops were saved; it would have failed to be effective if the ravages of the maggots had been far advanced. We have discussed the insecticidal value of commercial fertilizers at some length in answer to several correspondents in the "Rural New Yorker" for March 24, 1894, p.184. Prof. J. B. Smith stated his views on the same subject in a note in the same paper for April 28, 1894.

This spring we potted out a thrifty cabbage plant, and May 25, 100 small maggots were introduced around the base of the plant. The next day when the maggots had become established on the root, 4 oz. of a solution of salt (1 pound to one gallon of water) was poured in an excavation around the base of the plant. This treatment resulted in the death of most of the maggots and the plant also; it was thus more effectual than the kainit of the same strength. Thus all the evidence is against the use of salt to destroy the maggots, unless it is desirable to destroy the plants at the same time.

Dry Lime or Lime Water.

Lime in a dry condition has been extensively used as a preventive against the maggots, but the literature contains only a few references of its use as a killing agent. In her report for 1881, Miss Ormerod says caustic lime was not very effective as it could not easily reach the roots. In 1888, the "Rural New Yorker" reported that plants treated with air-slaked lime to kill the maggots suffered more than those untreated. Last year Butz and Baldwin in Pennsylvania, and Washburn in Oregon used the dry lime with partial success. It is thus very doubtful if the lime used dry will destroy any of the maggots.

Lime Water.—The source of nearly all the recommendations for the use of lime water to destroy the maggots is a report by Miss Ormerod in 1881 from one of her correspondents who soaked the lime 48 hours and then applied it with apparent good results. We doubt if lime in any form will either prevent or kill the maggots.

(*c*) *By the use of Insecticidal Substances.*

London Purple or Paris Green.

London Purple.—Prof. Cook experimented with this in 1887. Several applications were made about the roots of early cabbage, beginning soon after the plants were set and continuing until after the flies had stopped egg-laying. "At this time an examination of the plants showed them to be nearly as badly infested with maggots as were the untreated rows."

Paris Green.—In 1886, Prof. Cook reported that Paris Green was used at a strength of 1 pound to 40 gallons of water for the maggots. "It neither injured the plants nor the insects." In 1890, Mr. Fletcher treated a dozen plants with it (1 lb. to 100 gals.); its application noticeably checked the growth of the cabbage, and it failed to kill the maggots.

Pyrethrum.

In 1886 and 1887 Prof. Cook tested this substance thoroughly, both as a powder and as a decoction in water, but without any effect whatever.

Tobacco Water.

In the "Country Gentleman" for 1859, p. 27, we find the first recommendation of this tobacco decoction to kill the maggots; it had been tried as a preventive several years before. The first experiment we find recorded is by Prof. Cook in 1887. He faithfully used a strong decoction "about radish plants for the destruction of the maggot, but all to no effect." This year Mr. Washburn has reported fairly good success from its use in Oregon. The evidence is not sufficient to recommend it as a destructive agent against the root maggots.

Kerosene.

In 1887, Mr. Goff used this substance on the maggots at work on cabbages. It proved fatal to both the plants and the insects.

Paraffin Oil.

This substance was mixed with water and used by some of Miss Ormerod's correspondents in England in 1881. It had but little, if any, effect on the maggots.

Soap Combinations.

Soap Suds.—In 1875, a correspondent to the "Country Gentleman" claimed to have killed the maggots by applying ¼ pint of a solution of 1 part soap to 12 parts of water; three applications were made during the season. In 1881, a correspondent reported to Miss Ormerod that drenching his cauliflower plants with strong soap suds had no effect on the ravages of the maggots. Prof. Cook, in 1887, also applied strong soap suds faithfully, 3 times per week on radishes and cabbages, with no apparent effect on the maggots.

Whale Oil Soap.—Prof. Cook also used this in his experiment in 1887, without success.

Whale Oil Soap and Sulphur.—This was recommended by Prof. Cook in 1883, but no one seemed to have tested it. It would doubtless be ineffective.

Soap Suds and Gas Water.—This was recommended by Mr. Major in 1829 in his "Treatise on Insects," but it was to be used to make the plants offensive to the Turnip Gall Weevil and not forthe Cabbage Root Maggot, on which it would doubtless have but little effect.

Boiling Water.

As Dr. Walsh states (Prac. Ent., i, 20), this method seems to have been first used by a Dr. Drew (who published it in the "New York Tribune" several years previous to 1865) on the Onion Maggot. In 1870, Dr. Riley recommended it for the radish maggot. In 1874, Prof. Cook says: "I have tried this with some, though not satisfactory success." Mr. Garfield reported in 1877 that he "poured boiling water upon the roots, and when the maggots were not too deep in the ground this was effective, but on the whole was not considered a successful remedy." Doubtless very hot water would kill the maggots could they be hit by it; but the soil would soon reduce the temperature of the water below the killing point, so its use would not be practicable.

Saltpetre (Nitrate of Potash).

In 1885, Dr. Lintner suggested that this substance be tested on the root maggots. Two years later, at Dr. Lintner's request, Mr. Goff thoroughly tested it. His experiment is so conclusive that we quote it in full: "On the first indication that the cabbage plants were infested, which was on May 31 a solution of saltpetre, at the rate of 1 lb. to 2 gals. of water, was applied to alternate rows of a plat of cabbage plants. The application, which was repeated on June 4, 10, and 16, was made by pouring one or two gills of the solution around the stem of each plant, from a sprinkling pot, from which the rose was removed. On June 18, an examination was made of all the plants in 4 rows of the plat, 55 in number, with the following results: Twenty-nine treated plants were attacked by 124 maggots. Twenty-six not treated were attacked by 25 maggots. One of the treated rows was on the outside of the plat, and these outside rows and the ends of the inside rows were more infested than the others. The greater number of maggots found in the treated rows is to be ascribed to this fact, and not to an assumption that the nitrate of potash attracted the fly. The last application was made but 2 days before the examination, but many live larvæ, that had apparently just hatched, were found in the treated rows, thus showing that the solution was harmless to the insects. As an additional test, a cabbage plant badly infested with maggots was placed in a flower pot, and treated repeatedly with a saturated solution of the salt, but no effect upon the insects was observable." In 1888, the editor of "The Rural New Yorker," p. 149, also reported no success from the use of this substance against the maggots.

Corrosive Sublimate.

An editorial in 1864 ("Country Gentlemen, p. 65) states that a contemporary recommends 1 oz. of this substance dissolved in 4 gals. of water to destroy the root maggots. A correspondent to a Canadian journal ("American Cultivator" for April 30, 1881) says all of the London market gardeners secretly use a solution of ¼ oz. of this substance in 4 gals. of water for these maggots. He had used the solution quite extensively, using enough to saturate the ground. But it is not clear from the account whether it is applied as a preventive or whether it kills the maggots. We have but little faith in its effectiveness, but it should be further tested. Remember it is a virulent poison and great care must be used in handling it.

Epsom Salts (Sulphate of Magnesium.)

In 1881, one of Miss Ormerod's correspondents reported fair success in destroying the maggots with a solution of this well-known cathartic. It might be well to test it on a small scale.

Liver of Sulphur (Sulphide of Potassium.)

In 1887, a correspondent ("Rural New Yorker," pp. 431 and 626) reported in detail some experiments by which he claimed to have killed maggots on his cauliflowers by pouring a large teaspoonful of a solution on this substance (1 oz. to 3 qts. of water at 100 degrees) on the soil around the stalk; 24 hours later the maggots were apparently dead, but his account of the appearance of his "dead" maggots strongly impresses one that he saw only puparia or the empty shells from which the flies had emerged.

The next year, at Dr. Lintner's suggestion, Mr. Goff carefully tested the substance as follows: "An ounce of it was dissolved in a gallon of water at a temperature of about 100°F., and when cold, 2 teaspoonfuls of the solution were poured about the stem of each plant. The first application was made May 5, which was before the plants had manifested any injury from the maggot. At this strength. the plants appeared to suffer somewhat, hence the latter applications, made May 21, and June 5, were reduced to ¼ of an ounce to the gallon, and about a gill of the liquid was poured about each plant. On June 6 examination showed that the plants were suffering from many live maggots, and there were no indications that the treatment had caused any diminution in the number." The substance has decided fungicidal properties, but the evidence thus far will not warrant its use by gardeners in fighting the root maggots.

Tansy, or Burdock Decoction.

Several years ago a contributor to the "New England Homestead" stated that the following decoction was a "dead shot for the maggot:" "Take green burdock leaves and stalks, run them through a hay-cutter, put them in a kettle or tub, and mash them with an old ax or mall, adding water and pounding them to a pulp. Let it stand over night. Have the decoction strong, and when you see the first signs of the maggot, use it. Apply it with a sprinkler by pouring it along the rows. I seldom have to apply it the second time." Dr. Lintner adds that "a strong decoction of tansy, where it is abundant, would probably be about as serviceable as the burdock." These recommendations seem to have received no further notice. We doubt if they can be depended on to destroy the maggots, but they should at least receive a thorough trial.

Mercury and Pulverized Earth.

The combination had been recommended in California for the Grape Phylloxera; and so Mr. Goff, in 1885, put a little of the mixture about cabbage plants infested with maggots. It "seemed to have a beneficial influence, but was not an entire success." Some dead maggots were found, but there were others alive, in immediate contact with the mixture.

McDougall's Sheep Dip.

In 1888, Mr. Goff diluted this substance with 5 parts of water and tested it on cabbage to kill the maggots. The insects were not injured but the plants were killed.

Zoektin Poison.

Mr. Goff tested this in 1888, using 1 oz. to 5 gals. of water. It proved fatal to both the cabbage plants and the insects.

Naphthaline.

In 1890, Prof. J. B. Smith reported an experiment by one of his correspondents with this substance. In its crude form it injured the plants severely, even more than did the purified form. It killed the maggots. Prehaps the substance will prove of value if applied in the soil with the McGowen Injector.

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1835. Macquart, Hist. Nat. des Insectes. Dipteres, II, 326. Original description. *Chortophila.*

1878. Meade, Ent. Mo. Mag., XIV, p. 250. Records finding a specimen in a Coll. of Anthomyiidæ received from Cambridge Museum. *Chortophila.*

1881. Hagen, Can. Ent., XIII., 49. Records Mead's note on specimen found in the Cambridge Collection. *Chortophila.*

Inchbald, The Entomologist, XIV., 290. Bred the insect from young Savoys. *Chortophila.*

1882. Lintner, Can. Ent., XIV., 96. Records the insect as a Beet Leaf-miner. *Chortophila.* (Same article in Rept. Ont. Ent. Soc. for 1882.)

Lintner, First Rept., p. 207-208. Description of the insect as a Leaf-miner of Beets. *Phorbia.*

1883. Verrall, Ent. Mo. Mag., XIX., 224. Records it from the Island of Arran; and places *villipes* Zett. as a synonym. *Chortophila.*

Meade, Ent. Mo. Mag., XIX., 214. Detailed descriptions. *Phorbia.*

1888. Stein, Entomoligsche Nachrichten, XIV., 370. Records the species as common throughout the summer in Saxony; and says it is synonymous with *floralis* Fall. *Chortophila.*

1892. Stein, Ent. Nachrichten, XVIII., 324 and 326. From an examination of type specimens in the "Fallen-Zetterstedt Collection" the author concludes that *Aricia villipes* Zett.=*C. floccosa* Mcq.; and that *floralis* Fall. is distinct from *floccosa* Mcq. The author is familiar with *floccosa*, and points out the difference between the two species; he records the capture of three specimens of *floralis* in August of that year.

1893. Meade, Ent. Mo. Mag., XXIX., 219. Comments on Stein's paper, and accepts *villipes* Zett.=*floccosa*; but says nothing of Stein's separation of *floccosa* from *floralis* Fall.

Phorbia floralis Fallén.

of Meigen, Zetterstedt, Schiner, and others.*

1826. Meigen, Syst. Besch. Insek., V., 165. Description of adults.

1834. Bouché, Natur. der Insek., bes. als Larv. u. Pup., p. 77. Larva and pupa described.

1845. Zetterstedt, Dipt. Scand., IV., 1536, 147. Description.

1853. Walker, Insect. Brittan., Diptera, II., 142. Describes it as common in England.

1862. Schiner, Fauna Austriaca, I., 646. Description from a Zetterstedt type specimen.

1872. Weyenbergh, Tijd. voor Ent. Nederl. Ent. Ver. Leiden, 2d ser., VIII., p. 131. Descriptions of the different stages, with habits and life history as a Radish pest. One plate of fairly good figures.

1880. Taschenberg, Prak. Insektenkunde, part IV., p. 132. Describes adults, and compiles Bouché's descriptions of the larva and pupa. (Bouché, however, does not say: "Also stark schwarz gekörnelt").

1882. Lintner, First Rept., p. 207. Mentioned.

1883. Meade, Ent. Mo. Mag., XIX., p. 214. Mentioned.

villipes Zetterstedt.

1883. Ormerod, Rept. for 1882, p. 10. Brief account.

1884. Ormerod, Rept. for 1883, p. 10–17. Brief account of life history, with general discussion of remedies.

1890. Ormerod, Man. of Inj. Insects, p. 25. Brief account.

1893. Ormerod Rept. for 1892, p. 146. Brief account.

1845. Zetterstedt, Dipt. Scand., IV., 1456, 67. Original description.

1862. Schiner, Fauna Austriaca, I., 650. Quotes Zetterstedt.

1883. Verrall, Ent. Mo. Mag., XIX., 224. Places *villipes* as a synonym.

1892. Stein, Ent. Nachr., XVIII., 324. Synonym.

1893. Meade. Ent. Mo. Mag., XXIX., 219. Mentioned.

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*In 1883, Meade had but little doubt that *floccosa* Macq was the same as the *M. floralis* of Fallén, Meigen, Zetterstedt, Schiner, and others; and (nothwithstanding Stein's separation of the species based upon an examination of Fallén's type) August 31, 1894, he writes me that he thinks that the *floralis* of Fallén, Meigen, and Zetterstedt is the same as *floccosa* Macq. I believe the *floralis* of the authors mentioned above and others, except Fallén, is the same as *brassicae* Bouché; therefore such references are here given a place in the synonomy. Fallén described his *floralis* in 1824 (Monog. musc. Sueciae, part VII., p. 71, No. 76 In Hagen's Bib. Ent. the date of this part is given as 1824, but Schiner quotes 1820). Meigen's description antedates Bouché's *brassicae* by 7 years; but, as Stein has shown, *floralis* is now occupied in the same genus by *floralis* Fallén, thus the rules of nomenclature require us to accept Bouché's name, even though Meigen described the same insect under another name several years before. Macquart's *floralis* seems to be different All the authors refer the species to genus *Anthomyia*.

Anthomyia radicum Linnaeus.

of Curtis and others.

1843. Curtis, Jour. Roy. Agr. Soc. of Eng., IV., 127-131. Same as in "Farm Insects," below.

1860. Curtis, Farm Insects, p. 141. Brief account, including description of adult and larva, with figure of adult; Mr. Meade writes me recently that this is a very good figure of *P. floccosa*. The same figure is used by most of the following authors; all use the generic name *Anthomyia*.

1867. Fitch, Eleventh Rept., p. 40. Is unable to distinguish between this species and *brassicae*.

1875 Packard, Rept. U. S. Geol. Surv., p. 762. Credits the species to Bouché, with Harris' *raphani* as a synonym. Brief account with remedies.

1880 Saunders, Can. Ent., XII., 212. Bred from young cabbage. (Also in Rept. Ont. Ent. Soc. for 1880, p. 10).

1882. Lintner, First Rept., pp. 171, 184, 186, 191-194, 196, 198. Good general account, mostly from Curtis and Fitch, with Curtis' figure.

1885. Goff, Third Rept. N.Y. State Agr. Expt. Station, p. 316. Experiments with Carbon Bisulphide on radishes.

1891. Fletcher, Bulletin 11, Ottawa Expt. Station, p. 29. Brief with remedies.

Fyles, Rept. Ent. Soc. Ont., for 1890, p. 44. Brief account as turnip pest.

raphani Harris.

1835. Harris, Cat. of Animals and Plants of Mass., p. 80. Name, but no description. Is always referred to the genus *Anthomyia*.

1841. Harris, Insects Inj. to Veg., p. 494. Brief account. (In Flint Edition of 1862, p. 616.)

1858. Osten Sacken, Cat. of Diptera of N. Am., p. 74. Mentioned.

1867. Fitch, Eleventh Rept., p. 59-61. Very good account with careful descriptions. Says it appears to be identical with *radicum* (which he fails to separate from *brassicæ* on p. 41.)

Glover, Rept. for 1867, p. 73 Reference to Fitch's account.

1869. Fitch, Illus. An. Reg. of Affairs, v. 96.

Packard, Guide to Insects, p. 411. Brief.

1870. Trimble, Am. Ent., II.. 273. Notes on habits and life history.

Riley, Am. Ent., III., 284. Recommends hot water.

1872. Glover, An. Rept., p. 134. Mention.

Quinn, Money in the Garden, p. 218. Brief account.

1874. Glover, Man. Notes on Diptera, p. 3. Reference.

Cook, Rept Mich. Bd. Agr., p. 121 Life history, brief; with remedies.

1877. Riley, Ninth Missouri Rept., p. 95. Mentioned.

1878. Osten Sacken, Cat. of N. Am. Diptera, p. 168. References.

1881. Cook, Can. Ent., XIII., p. 198. Carbolic acid as preventive. (Also in Rept. Mich. Hort. Soc. for 1881, p. 213, and in Rept. Ont. Ent. Soc.

for 1881, p. 26. Paper was first read before the Am. As. Adv. Sci. at Cincinnati, O.)

1883. Reed, Rept. Ent. Soc. Ont. for 1882, p. 53. Mentioned.

Cooke, Inj. Insects, p. 328. Brief account.

1884. Lintner, Count. Gent., LXIX., p. 677. Mentioned.

1885. Goff, Third An. Rept. N. Y. State Agr. Expt. Station, p. 196. Careful experiments against.

Lintner, Second Rept., p. 28. Mentioned.

1886. Goff, Fourth An. Rept. N. Y. State Agr. Expt. Station, p. 222. Experiments with carbolic acid.

Fletcher, Rept. for 1885, p. 15. Life history, brief, with good discussion of remedies.

Cook, Rept. Mich. Bd. Agr., p. 38 and 39. Experiments with kerosene and carbolic acid emulsions.

1887. Cook, Rept. Mich. Bd. Agr., p. 42. Negative experiments with several insecticides.

Cook, ibid. p. 449-450. Details of experiments to show that the onion, cabbage, and radish maggots are the same species or varieties; and conclusions regarding remedies.

1888. Gillette, Can. Ent., XX., 133. Parasite.

Fletcher, Rept. for 1887, p. 23. Brief account, with good discussion of remedies.

Hulst, Bulletin 50, N. J. Fxpt. Station, p. 12. Mentioned.

1891. Fyles, Rept. Ont. Ent. Soc. for 1890, p. 454. Good account of habits.

In the following references the scientific name of the insect is not mentioned; the pest is designated by one of its common names, this depending upon the plant attacked, as the Cabbage, the Cauliflower, the Turnip, or the Radish Fly or Maggot.

1846. Kirby and Spence, Int. to Ent., p. 140. Infesting Cauliflowers.

1857. Saunders, Edgar., Count. Gent., p. 319. Recommends tobacco dust. Cabbage Fly.

"T.", ibid. p. 47. Success with Superphosphate of Lime; negative results with other substances. Cabbage Fly.

1858. Editorial in Count. Gent., p. 26. Thinks Clump-rooted cabbage caused by fly. Radish and Turnip maggots mentioned.

Henderson, ibid., p. 159. Thinks "Club-foot" caused by fly, and advises lime.

1859. Count. Gent., p. 127. Says tobacco water kills. Cabbage Maggot.

1861. Gregory, Count. Gent., p. 319. Advises lime for Cabbage Maggot.

1864. Count Gent., p 224. Turn the chickens into the patch for the Cabbage Fly.

Editorial in Count. Gent., p. 65. Says a contemporary recommends corrosive sublimate for Cabbage and Cauliflower Maggots; should first be well tried.

1869. Riley, First Missouri Rept., p.156. Radish Maggot mentioned.

1872. Brill, Farm Gardening and Seed Growing, p.20–21. Maggots as the cause of "Club-root" in Cabbages, Cauliflowers, etc. Believes the Cabbage and Radish Maggots are the same.

1875. "J. H. G.", Count. Gent., p.392. Asks for a remedy for Cabbage Maggots.

"W. F. P.", ibid p.454. Kills Cabbage Grub with soap and water.

Editorial in ibid. p.488. Quotes Henderson that "Club-foot" is caused by an insect.

Philbrick, ibid., p.505. Says it is not generally believed that "Club-foot" is caused by an insect, also that bone dust does not prevent; says rotate crops.

1877. "W. H. J.", Count. Gent., p.236. Nearly two acres of cabbage destroyed by maggot; ruta bagas along side also attacked.

Garfield, Chas. W., Rept. Mich. Bd. Agr., p.61. Careful expts. with insecticides for Cabbage, Radish, and Turnip Maggots.

1879. Talcott, Count. Gent., p 85. Lost his whole turnip crop in 1878 and inquires for a preventive of the Turnip Fly.

"W. H. J.", ibid., p.151. In answer to Talcott, says the Cabbage Maggot has conquered them.

"C. D. A.", ibid, p.167. Says Mr. Will used salt successfully.

Philbrick, ibid., p.183. Says the Maggots have nothing to do with the "Club-foot" Mentions Tillinghast's theory in regard to the life history of the maggot. Only remedy is to destroy the eggs by rubbing the stems.

Tillinghast, ibid., p.774. Discusses the theory of "Club-foot."

Henderson, ibid., p.807. Strongly advises lime, and reiterates his belief that the "Club-foot" is caused by the maggot.

1880. Philbrick, Count. Gent., p.23. Has found maggots in great abundance where there was no "Club-foot."

Hewes, ibid., p.39. Says salt prevents "Club-foot" as the maggot cannot live in it.

Tillinghast, ibid., p.438. Says that no one has disproved his theory that the maggots are the larvae of the Striped Flea Beetle.

West, ibid., p 472. Thinks "Club-foot" due to maggot. Negative expt. with salt, lime, and bone dust. Answers Tillinghast by breeding the perfect insect—a fly.

1881. Cook, Proc. A. A. A. S. for 1880, p. 669-670. First account of use of Carbon Bisulphide against the Cabbage Maggots.

"E. L. C.," Am. Cultivator, for April 30. Says that soot is good, and strongly recommends Corrosive Sublimate. Cabbage and Cauliflower Maggot.

"Horticola," Rur. N. Yorker, p. 465. Recommends puddling in lime and soot for Cabbage Maggot.

1883. Barnard, Proc. Biol. Soc. Wash., Dec, 1883. (Account in Psyche, IV., pp. 134, 143., describes his "Nether-inserter" and its use against various insects, the Cabbage Maggot included.

1884. Cook, Rept. Mich. Hort. Soc., p. 204. Soap and kerosene for Anthomyiians, with instrument for applying the liquid.

1885. Lintner, Second Rept., p. 35. Reference to Barnard's "Nether-inserter" for Cabbage Maggot.

Fletcher, Rept. for 1884, p. 6. Reports Cabbage Root-fly very injurious.

1886 Fletcher, Rept. for 1885, p. 6. Cabbage Maggot reported in Ontario and Vanc. Island

Fletcher, ibid., p. 15. Habits of a Turnip Maggot, *Anthomyia* sp.

Cook, Rept. Mich. Bd. Agr., p. 38. Experiments with kerosene emulsion against the Radish Maggot.

Cook, ibid., p. 41. Experiments against the Cabbage and Radish Maggots with several insecticides.

Cook, Rept. Mich. Hort. Soc , p. 523. Says kerosene emulsion and carbon bisulphide will surely kill. Gas lime also effectual. How to use the two former. Art. by Henderson quoted from Rural N. Yorker, in which he says lime and guano are only effective on the early stages of the Maggots. Radish and Cabbage Maggots.

"C. E. P.," Rur. N. Yorker, p. 254. Recommends concentrated fertilizer in hill. Cabbage Maggot.

Rur. N. Yorker, p. 338. Answer to "M. M. L." Advises lime and any concentrated fertilizer. Cabbage Maggot.

Ibid., p. 643. Answer to "W. J. P.," advises sandy soil for Radish Maggots.

"J. H.," Rur. N. Yorker, p. 840. In trying to kill Cabbage and Cauliflower Maggots by puddling plants in Insect Powder and Paris Green, the plants were killed.

1887. Henderson, Gardening for Profit, p. 319. Says the insect is the cause of "Club-foot." Expt. with manure and bone dust. Curious theory of the life history of the Cabbage Maggot.

Henderson, Rur. N. Yorker, p 133 General account of Cabbage Maggot, with an expt. with guano and cotton seed meal fertilizers

"N. W. S.," Rur. N. Yorker, p. 238. Advises Henderson to use Kainit, but says it will not affect the maggot after it has hatched.

Perkins, Rur. N. Yorker, p. 431 Tells how he kills Cauliflower Maggots with Liver of Sulphur.

"H. A. M.," Rur. N. Yorker, p. 530. Says Cook's emulsion cost him 2000 cauliflower plants. Now hires women to haul the eggs and young larvæ into the middle of the rows where they perish.

Hoskins, Rur. N. Yorker, p 542. Recommends lime for Cabbage Maggot.

Perkins, ibid., p. 626. Again details his expts. with Liver of Sulphur.

Henderson, ibid., p 578. Says he feels certain that "nothing will kill the Cauliflower maggot, which will not at the same time kill the plant." Says "H. A. M.'s" plan was adopted by them several years before, and it is the only thing that will save the crop

Goff, ibid., p. 135. Advises sandy soil to prevent Radish Fly.

Rur. N. Yorker, p. 154. In answer to 'J. J. C.," advises Kainit to destroy Cabbage Maggots.

1888. Rur. N. Yorker, p. 149. Negative results with lime and nitrate of potash against Cabbage Maggots.

Goff, Sixth Rept. N. Y. State Agr. Expt. Station, p. 96. Negative result with lime for Cabbage Maggot.

Cook, Rept. Bd. Agr., p. 43. Saved radishes by a protection; has further proof that Onion, Cabbage, and Radish Maggots are identical. Radishes as trap crop.

Cook, Bulletin, 39, Mich. Expt. Station, p. 10. (Also in Rept. Bd. Agr., p. 225.) More convinced that Cabbage, Radish, and Onion Maggots are the same. Advises radishes as trap crop.

Howard. G. H., in Burpee's How to Grow Cabbage and Cauliflower, p. 47. Says muriate of potash and wood ashes are sure remedies.

Fletcher, Rept. Ont. Ent. Soc. for 1887, p. 14. Carbolic acid and gas lime for root maggots of Radish and Cabbage.

Fernald-Maynard, Rept. Mass. Bd. Agr. for 1887, p. 94. Brief.

1889. Lintner, Count. Gent., p. 440. Discussion of remedies for Cabbage Maggot on Cauliflower.

Dunning, Pop. Gardening IV., 24. Expt. with liquid manure and lime for Cabbage Maggot.

Riley and Howard, Insect Life, II., 86. Ref. to Dunning's expt.

Rur. N. Yorker, p. 495. Ref. to Dunning's expt.

"H. A. M.," Rur. N. Yorker, p. 678. Expt. with Sulphur.

Fletcher, Rept. for 1888, p. 68. Mention of Cabbage Anthomyian.

1890. Greiner, How to Make a Garden Pay, p. 98. Considers the Cabbage, Radish, Turnip, and Onion Maggots the same insect. Radishes preferred. Remedies discussed.

Smith, Bulletin 75, N. J. Agr. Expt. Station, p. 12. Expt. with kainit against Cabbage Maggot. P. 20, expt. with naphthaline against Radish Maggot. P. 26, expt. with kerosene emulsion on Radish Maggots. P. 29, expt. with Hellebore for maggots.

1891. Riley and Howard, Insect Life, III., 247. Hellebore for Cabbage Root-maggot.

Fletcher, Insect Life, IV., 13. Late planting for Cabbage Maggot.

Schwarz and Fletcher, Insect Life, IV., 27. Discussion of the parasitic habits of *Aleochara*, which Fletcher bred from Cabbage Maggot.

Smith, Bulletin 85, N. J. Expt. Station, p. 8. Discussion of merits of tobacco, kainit and nitrate of soda for Radish and Cabbage maggots.

Weed, Insects and Insecticides, p. 188. Radish Maggot mentioned.

Crozier, The Cauliflower, p. 96. Radish maggot mentioned.

1892. Rawson, Suc. in Mark. Gardening, p. 228. Radish Maggot prefers radishes to cabbage, cauliflower, or onions. Advises lime, and says kainit or muriate of potash kills eggs and maggots by contact.

Barnhardt, Insect Life, V., 136. Expt. with carbon bisulphide for Cabbage maggot.

Forbes, Insect Life, V., 74. Cabbage Maggot mentioned.

Smith, Insect Life, V., 94. Mention of Cabbage and Cauliflower Root-maggots.

Fletcher, Insect Life, V., 124. Hellebore and kerosene emulsion successful in gardens, but not in field, for Cabbage, Radish, and Turnip Maggots.

Weed, H. E., Bulletin 21, Miss. Agr. Expt. Station, p. 15. Radish Maggot mentioned.

1893. Lintner, Ninth Rept., p. 418. Kainit for Cabbage Maggot.

Fletcher, Rept. for 1892, p. 145. Similar to account in 1892, above.

Smith, Rept. N. J. Expt. Station for 1892, p. 391. Recommends hellebore for Cabbage and Cauliflower Root-maggots.

Smith, Insect Life, VI., 96. Reference to Fletcher's use of hellebore for Cabbage Maggot.

1894. Fletcher, Rept. for 1893, p. 19. Cabbage Maggots mentioned. (Also in Rept. Ont. Ent. Soc. for 1893, p. 10.)

Washburn, Bulletin 31, Oregon Expt. Station, p. 82. Expt. with lime, ashes, and tobacco water on Radish and Turnip Anthomyiians.

Notes on the above Synonomy and Bibliography.—Although containing over 230 references, the Bibliography is incomplete. The pest is so well known, so widely distributed, and so destructive that it has attracted much attention for more than 50 years; and in consequence it has been often discussed in our economic entomological literature and in Agricultural periodicals. I have had access to nearly all of the strictly entomological publications of the United States, but I have seen only a few complete files of agricultural publications (the *Country Gentleman* is the only weekly general farm paper among these). The reports in these periodicals are often valuable, as they usually give the results of experiments with various substances; thus it is to be regretted that this part of the bibliography could not be made more complete. It is also incomplete in respect to foreign publications as only those are included to which I have had access. I believe, however, the bibliography contains nearly all of the more important articles on this pest in the world's literature.

Economic writers on the pest have heretofore paid little or no attention to the systematic phase of the subject. Nearly every economic writer, whether European or American, has used, scarcely without question, the name *brassicæ*, given to the insect by Bouché in 1833; while Schiner is the only Dipterologist, so far as I know, who has expressed any opinion on Bouché's species. However, the flies, which I bred in large numbers from Cabbage Maggots, were determined by Mr. Meade as *Phorbia floccosa* Macq. Coupled with this fact, I soon found that all the specimens of Cabbage, Cauliflower, Radish, or Turnip Maggots or Flies to which I could get access through entomological friends,* belonged to this same species—*floccosa*. These facts at once caused me to wonder if all these years this common pest has been discussed under the wrong name. After a laborious critical study of all accessible descriptions and accounts of the insect, with my specimens always at hand, I have reached the conclusion that the Cabbage Maggot should be called *Phorbia brassicæ* Bouché.

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*Messrs. G. C. Davis, J. Fletcher, L. O. Howard, and Dr. Lintner have kindly sent me their material in this line for study. This has enabled me to settle many disputes and unsolved questions.

Realizing the responsibility incurred by the wide divergence from the opinions of systematists which my synonomy represents, I deem it necessary to offer a detailed explanation of the facts from which I reached my conclusions. For 50 years past, so far as I can discover, every economic writer, whether American or European, has called the Cabbage Maggot *Anthomyia brassicæ* Bouché. But I have found only two or three references to Bouché's species in the systematic literature of the Anthomyiians. Westwood, Osten Sacken, and Leunis apparently accepted *brassicæ* Bouché without question; but Schiner thought it probably identical with *ruficeps* Meigen. Later Dipterologists seem to have overlooked the species entirely.[*] Naturally the question arose: What is *Anthomyia brassicæ* Bouché.

Mr. Meade answers the question for me in a recent letter as follows: "There is no doubt that the true Cabbage Fly is the *Phorbia floccosa* of Macquart, but this species has been confounded with *Anthomyia radicum* Linn. . . . I have no doubt that Bouché confounded *P. floccosa* and *A. radicum* together. . . . . I am convinced that Bouché, Curtis, Zetterstedt, and others did not know the difference between these two species and confounded them together." The question is answered by Mr. Stein in a recent letter to me, thus: "I believe that *Phorbia floccosa* Macq., Rond., Mde. and *A. brassicae* Bouché are synonymous. The first name has the priority." I had reached the conclusions represented in my synonomy before receiving either of the above answers; and after a careful review of the whole subject, I still adhere to the same opinions.

I believe with Mr. Stein that *floccosa* Macq. and *brassicæ* Bouché are synonymous; but Macquart's description did not appear until 1835,[*] while Bouché had twice described his *brassicæ* before this. His first description in 1833 is brief, but the next year it was given in detail and both accounts are accompanied by accurate descriptions of the larva and puparium. Bouché's *brassicæ* thus has the priority over *floccosa* Macq.

I believe with Mr. Meade that *floccosa* Macq. has been confounded with *radicum* Linn. by some authors, as my synonomy shows. But I do not think that Bouché confounded them. It is true that Bouché describes only the larva and puparium of *radicum*, but he makes these entirely distinct from his *brassicæ*, thus indicating that he knew *radicum* Linn. All European authors seem to have accepted Bouché's descriptions of the early stages of *radicum*, for their accounts are but compilations from Bouché. I think a careful comparison of Bouché's descriptions of the adults of his *brassicæ* with specimens of *floccosa* Macq. will convince any fair critic that he had Macquart's species, and not *radicum* Linn., before him. I believe Bouché saw the characteristic tuft of hairs on the hind femora, for he says: "Schenkel aussen vielborstig;" no similar expression occurs in his descriptions of any other Anthomyiian. A further strong argument for the validity of Bouché's species is to be found in the accurate detailed descriptions of the larva and puparium. These descriptions of the early stages of the pest are the models from which nearly all of the later accounts have been taken; the careful descriptions of Dr. Fitch are the only notable exceptions of original work. Westwood has testified to Bouché's capabilities and abilities for observation (Gard. Mag. for 1837, p. 243.) Furthermore, I think but few authors have confounded *radicum* Linn. and *floccosa* Macq. A study of the descriptions of *radicum*, *brassicæ*, and *floccosa* in the works of Meigen, Bouché, Macquart, Walker, and Schiner shows that in every case the abdomen of the male insect of *radicum* is described as sub-elliptical (Mr. Meade says: "short, wide, somewhat pointed"). While all the descriptions of either *floccosa* or *brassicæ* agree that the male abdomen is sub-cylindrical, "streifenförmig," or long and narrow. Macquart puts *radicum* and his *floccosa* in different groups on this difference in the shape of the abdomen. I have not seen Zetterstedt's work. In 1867, Dr. Fitch pointed out that the slight difference indicated by Curtis between *brassicæ* Bouché and the species supposed by Curtis to be *radicum* Linn. were hardly more than accidental and not of sufficient value to indicate a specific difference between the insects. In a recent letter Mr. Meade incloses Curtis' figure of *radicum* with the remark that "it gives a very good figure of *P. floccosa*." I have never seen a specimen of *radicum* Linn., and the only authentic record that the species occurs in this country is the fact that a specimen was found in the Cambridge Collection by Mr. Meade in 1878. From the above evidence, the only conclusion I can reach is that *brassicæ* Bouché is a valid species, has priority over *floccosa* Macq., and is the name to be applied to the Cabbage Maggot unless some other name appears which antedates it.

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[*] There is an older *Anthomyia brassicæ* described by Wiedemann several years before Bouché published his description. However, Wiedemann's species was soon placed in the synonomy of *A. radicum* Linn. by Meigen seven years before Bouché wrote; and this synonomy has been accepted by Schiner and Meade.

[*] I have examined his earlier work on the "Insectes Dipteres du Nord de la France (1826-1834)", and find no reference to *floccosa*; and all the references to *floccosa* I have seen refer to his later work (1835) for the original description

In 1883, Mr. Meade stated in his description of *floccosa* Macq. that "there is but little doubt that this species is the same as the *M floralis* of Fallén, Meigen, Zetterstedt, Schiner, and others; for the general descriptions of both species agree together, though none of the last-named authors mention the tufted femora." In a recent communication to me Mr. Meade reiterates the same opinion. However, Mr. Meade has not yet, in print, removed the question mark from his reference of *floralis* to the synonomy of *floccosa*. In 1882, Miss Ormerod had specimens of the Cabbage Maggot Fly determined by Mr. Meade, and she has since used the name *Anthomyia floralis* Fallén. This possible identity of these two species is a very important question, for *floralis* antedates Bouché's *brassicae* by several years. Thus, if their identity could be shown beyond a doubt, the Cabbage Maggot would have to be called *Phorbia floralis* Fallén.

I do not know who first suspected the identity of *floccosa* and *floralis*. I have seen no record earlier than Mr. Meade's. In 1888, Mr. Stein recorded "*Ch. floccosa* Macq. (=*floralis* Fall.) common throughout the whole summer." Four years later, however, Mr. Stein critically examined the Fallén-Zetterstedt Collection at Lund and has published (Ent. Nach., xviii, 326) the following account of a species which he found in the collection under the name *A. floralis* Fall.: "*A floralis* (147) Ich habe diese Art mit andern dipterologischen Freunden bisher für identisch mit der überall gemeinen *Ch. floccosa* Mcq. Rd. gehalten und glaube auch, dass Schiner bei Beschreibung seiner *A. floralis* letztere vor sich gehabt hat; er sagt zwar in der Anmerkung, dass er ein Zetterstedt'sches Originalstück gehabt habe, doch ist dem kein Wert beizulegen, da ja Zetterstedt die Arten oft genug verwechselt hat. Die Fallen'sche Type von *M. floralis* ist, wie mich der Augenschein gelehrt hat, verscheiden von *Ch. floccosa*, wenn sie auch die grösste Ahnlichkeit mit inr hat. Sie unterscheidet sich durch die Beborstung der Hinterschenkel, die auf der unterseite an der Basis nicht dicht und kurtzborstig sind, sondern mit gleichlangen, zeimlich weitläufig stehenden Borstenhaaren besetzt sind; ausserdem ragen die Lamellen auf der Unterseite des Hinterleibs nicht hervor, wie es gewöhnlich bei *floccosa* der Fall ist. Die Fleige scheint bei uns selten zu sein, ich habe sie wenigstens zum ersten Mal in diesem Jahre im August in 3 Exemplaren gefangen. Ubrigens steckt in der Sammlung unter dem Namen *floralis* auch ein Stück von *villipes*." Mr. Stein writes me that he still holds the same opinion. This direct evidence from an examination of specimens by a Dipterologist familiar with the Anthomyiians, seems to me conclusive. Yet Mr. Meade, in commenting on Mr. Stein's paper in 1893, does not mention this important discovery, although he accepts other synonymic notes made by Mr. Stein at the time. Mr. Meade's belief in the identity of *floccosa* and *floralis* seems to be based entirely on a comparison of descriptions. One ought not to entirely ignore the direct evidence of a competent observer like Mr. Stein, so I cannot escape the conclusion that the well-known name, *brassicae* Bouché, by which the Cabbage Maggot has been described the world over by economic writers, must be accepted, for the present at least; there is a possibility, of course, that later investigations may bring to light new evidence to show that Bouché's *brassicae* is identical with *floralis* Fall., or perhaps some still earlier name, in which case the rule of priority would decree that the earliest name be used instead of *brassicae*.

There is no doubt that several authors have written of the Cabbage Maggot under the name *floralis* Fall., as I have indicated in the synonomy.

In 1862, Schiner said *brassicæ* Bouché was probably a synonym of *A. ruficeps* Meigen. Could the identity of these two species be proven, Bouché's name would fall and the Cabbage Maggot be known as *Phorbia ruficeps* Meig., as Meigen's description appeared seven years before Bouché wrote. I think the facts do not warrant this conclusion of Schiner. While studying Meigen's descriptions of Anthomyiians, I was struck with the sim.

ilarity between the descriptions of his *ruficeps* and of *radicum* Linn. Careful comparison showed these descriptions to be almost identical, word for word! The only differences between the insects, indicated by the descriptions, relates to a slight difference in the coloring of the face, the scales, and the halteres; the face of *radicum* is said to be "schwarzschillernd" and the scales and halteres yellowish, while in *ruficeps* the face is "rostrothem" and the scales and halteres are white (Mr. Meade describes the face of female *floccosa* as either red or black). The female of *ruficeps* was unknown to Meigen, and in fact the species does not seem to have been recognized since Meigen's time; Schiner had not seen it. Thus all the evidence I have found leads me to believe that *ruficeps* Meig. should be placed in the synonomy of *Anthomyia radicum* Linn.; at least there is scarcely a chance of its being identical with *brassicæ* Bouché.

My breeding experiments, and a study of flies bred from maggots infesting radishes in different parts of the country, lead me to believe that the Radish Fly or Maggot of economic entomological literature is identical with the Cabbage Maggot. A study of the literature brings out the following evidence.

European writers, following Bouché's lead, have called the Radish Fly, *Anthomyia floralis* Fallén. While American entomologists have usually adopted Dr. Harris' name, *Anthomyia raphani;* some use *radicum* Linn. Bouché's description of the larva and puparium of *floralis* Fall. agrees closely with his descriptions of the Cabbage Maggot, and with my specimens; he describes it as feeding on *Raphanus sativus*. Taschenberg compiles his descriptions of the early stages of *floralis* Fall. (as the "Rettichfliege") from Bouché, introducing, however, the phrase "ist also stark schwarz gekörnelt," which is very misleading as can be seen by referring to the accounts of both authors. There are no specific differences between Taschenberg's descriptions of the flies of *floralis* and *brassicæ*. Miss Ormerod has used the name *Anthomyia floralis* Fall., the Radish Fly, since 1882 for the maggot doing the most damage to cabbage in England. Taschenberg and Schmidt-Göbel record *brassicæ* Bouché as attacking the various species of *Brassica*, *Raphanus sativus* and *radiola*, Turnips, and Stocks (Matthiola).

In this country, Dr. Harris gave a name to a Radish Fly in 1835, but published no description of it until 1841. None of Dr. Harris' types are known to be in existence, and no one has since definitely characterized the species as distinct from *brassicæ* Bouché. In 1867, Dr. Fitch was unable to separate his cabbage or turnip flies or maggots from those bred from radish, yet he described them separately as *brassicæ* and *raphani*. It is not until 1882 that we again find the distinctness of *raphani* seriously questioned by entomologists. Then Dr. Lintner, in discussing *raphani* thought it quite probable that it was identical with *radicum* Linn.; Dr. Fitch had reached a similar conclusion in 1867, but he was not able to separate *radicum* and *brassicæ*. There is a single specimen in existence labelled *raphani* by Dr. Fitch, but it is in too poor condition to identify definitely; yet Dr. Lintner, in a foot-note gives a description of the wing venation which I think agrees closely with that of *brassicæ* Bouché. In 1887, Prof. Cook recorded some experiments which proved that the Cabbage and Radish Maggots would breed freely on either food-plant and were thus doubtless identical; his conclusions from these experiments led him too far, however, for he came to believe that the maggots infesting onions (*Phorbia ceparum* Meig.), beans (*Phorbia fusciceps* Zett.), and raspberry canes (an Anthomyiian, possibly new) were either identical with or but varieties of *brassicæ* Bouché.* During the last few years, all Americans have been more and more inclined to regard the Cabbage and the Radish Maggots as identical specifically.

I think there is much in the above evidence to support the conclusion that the radish and the cabbage maggots are the same insect; my breeding experiments and the above mentioned examination of Radish Flies from different parts of the country, also strongly support this conclusion.† Therefore, I have included all references to the Radish Fly or Maggot in the bibliography. MARK VERNON SLINGERLAND.

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* These determinations are made from specimens received from Prof. Davis, including some of the specimens bred by Prof. Cook, and from Mr. Fletcher.

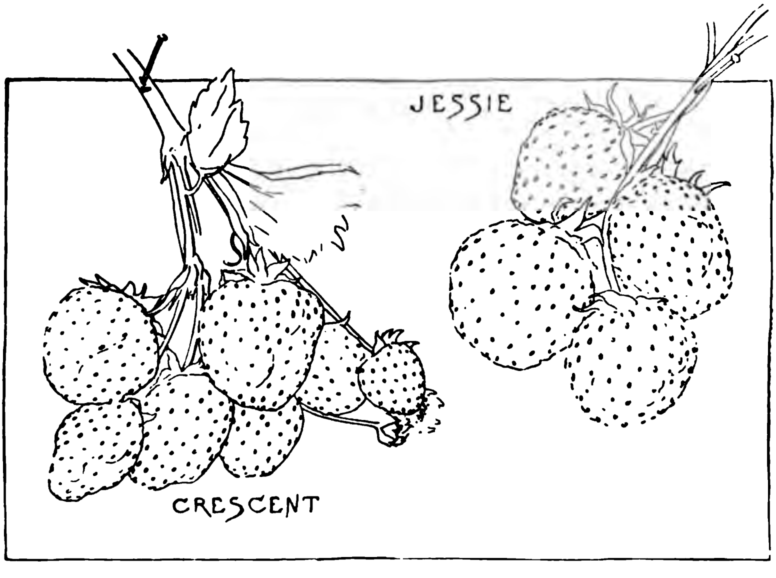
† There are two other Anthomyiians recorded as feeding on cabbage and radish namely, *Phorbia fusciceps* Zett. and *Anthomyiia radicum* Linn. The former is very common and the latter rare in this country, where I believe, however, their attacks upon cabbages or radishes are exceptional.

Bulletin 79. **December, 1894.**

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

VARIETIES AND LEAF-BLIGHT
OF THE
STRAWBERRY.



By L. H. BAILEY.

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BULLETINS OF 1894.

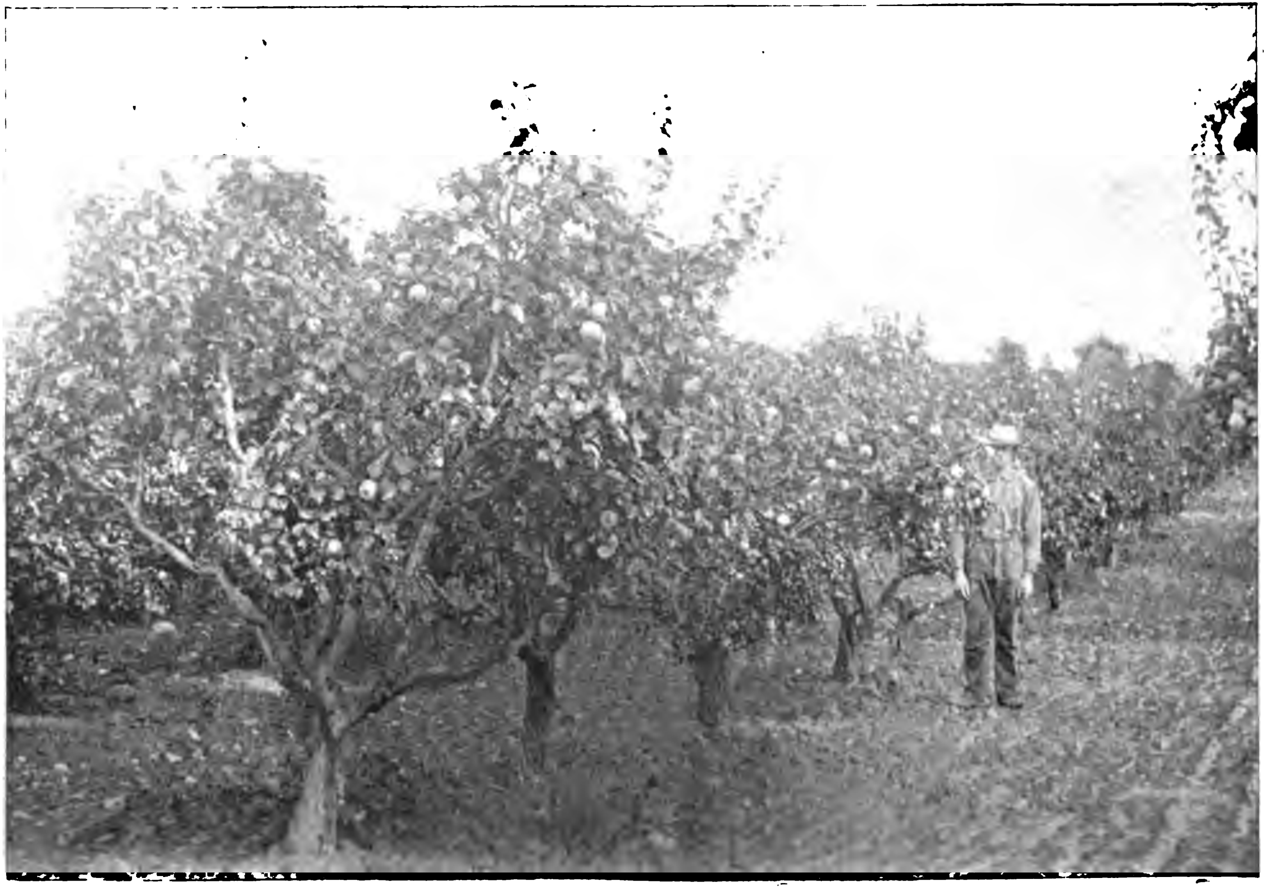
62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf Blight of the Strawberry.
80. The Quince in Western New York.

CORNELL UNIVERSITY, ITHACA, N. Y., Dec. 10, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

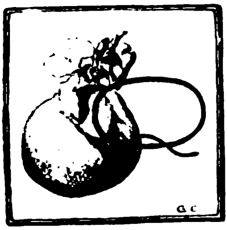
Sir :—There are two questions which the strawberry growers of western New York are always asking: What are the best varieties? How is the leaf-rust to be kept in check? I have endeavored to answer these questions, and I submit the attempt for publication under Section 87, Chapter 675, of the Laws of 1894.

L. H. BAILEY.



1. *A model Quince Orchard, 18 years old,—fed, tilled, pruned and sprayed.* (*T. C. Maxwell & Bros., Geneva.*)

THE QUINCE IN WESTERN NEW YORK.



QUINCES are more largely grown in western New York than elsewhere in the Union. The industry has grown up slowly and quietly, and has not attracted general attention, yet, in its way, it is one of the important agricultural interests of the state. Quince growing can never assume the proportions of other orchard industries, because of the limited demand for the fruit; and for this reason, also, the most careful attention must be given to marketing the crop and to reducing the injuries from a number of insect and fungous enemies. The crop has much in its favor; the trees are almost sure to bear nearly every year if they receive good care, and they are so small that spraying and thinning can be practiced with ease; there are no climatic difficulties to be overcome, and the fruit is not perishable. Added to this is the sentimental interest which attaches to the crop, for the quince tree, both in flower and fruit, is the handsomest fruit tree of temperate climates. The large flowers are borne upon the extremities of leafy shoots of the season, and they therefore appear after the leaves are grown and they clothe the whole exterior of the tree with a mantle of snowy whiteness at a time when the bloom of springtime already begins to wane. The golden fruits are all in sight, hanging upon the ends of the twigs, and they are more showy than oranges. It is easy to accept the supposition that the quince was the golden apple of the Hesperides of the early Greek writers.

The quince plantations of western New York range in size from a few square rods to several acres in extent; and the famous orchard of T. C. Maxwell and Bros. at Geneva, comprises about thirty acres. In general, the larger or more important plantations are well cared for; and yet there are certain directions in which the treatment of most of them might be improved. I have given particular attention to the quince interests of the Fifth Judicial Department during the year, and have been able to draw certain conclusions from the study; and to this account I also add the results of three years' observation of varieties made upon our own grounds, and a sketch of experiments to control the leaf-blight.

Soils and fertilizers.—It is generally agreed, in this state, that the best soil for quinces is a heavy clay loam; that is, a clay soil which has become friable by good cultivation, fertilizing and draining. While the land should be well drained, it should nevertheless retain moisture more readily than is necessary for most other orchard fruits. Quinces often thrive upon light lands, but they are rarely as productive and long-lived as upon the heavier lands which I have described. According to Meech,* "in selecting soils, the first choice should be a strong loam, with enough sand in its composition to make it work easy. In a deep, strong soil the trees should not be expected to come into as early bearing as in the sandy soil, because the greater vigor of growth does not soon tend to the formation of fruit buds; but when they do bear they make up for any lost time by the abundance and quality of the fruit, and greater longevity, and immunity from disease."

There has been no explicit field experimentation in this country, so far as I know, to discover the particular needs of the quince in matters of food; but the same general principles which apply to other tree fruits will no doubt apply to this, and these matters are discussed in Bulletin 72. It is now held that the controlling factors in orchard fertilizers should be potash and phosphoric acid rather than nitrogen; this last element induces growth, and the trees themselves may be supposed to register the needs in this direction. Trees which are yellow and stunted need either moisture or nitrogen, or both—providing they are not attacked by insect or fungous enemies—and these can be supplied by means of shallow tillage and nitrogenous or fibrous fertilizers, such as barn manures, green catch crops, or nitrogen in commercial form. If the trees are very dark green, with large leaves, and are making heavy growth at the expense of fruitfulness, either nitrogen or excessive cultivation should be withheld for a time; or the trees may be severely headed-in, as explained farther on, although this last resort treats the symptoms rather than the fundamental difficulty. For potash, I should, in general, advise the best grade of muriate of potash, although wood ashes is excellent when the price is not too high for the quality of the material. Muriate of potash containing 50 per cent. of actual potash, may be applied at the rate of 200 to 300 pounds to the acre, sown broadcast and harrowed in. It may be applied in the fall or in earliest spring. Phosphorus may be obtained in bone compounds or dissolved South Carolina rock, applied at the rate of 200 to 500 pounds to the acre. It is frequently said that common salt is an indispensable food for the highest production of the quince, but I am unable to find any reason for such opinion, and I do not know that any better results follow its application to quinces than to pears and other fruits. Salt is a conservator of moisture, and in this respect it may have especial value for quinces, inasmuch as these trees thrive best upon a rather moist soil.

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*Quince Culture, 34.

2.—*The orchard that shifts for itself,—sod, borers and leaf-blight, but no quinces.*

The quince orchard should be kept in clean tillage. Orchards in sod generally give only indifferent results over a series of years, and they are especially liable to the ravages of borers and fungi. It is indisputable that the most economical means of securing and maintaining fertility and moisture is very frequent stirring of the surface soil. Fig. 2 shows an average condition of a soddy quince orchard during the past season; and one does not need to look twice to see that the harvesting of the crop does not impose serious difficulties!

The quince is a shallow rooted tree, and orchards which have been kept in sod cannot be plowed deeply. In many cases it is better to break up such orchards by thorough harrowing or cultivating in spring when the sod is soft, rather than by attempting to plow. Mulching quince trees is often recommended, but it is evident that this practice cannot be applied to large orchards; and, at best, it is a poor substitute for tillage, unless, possibly, in in the case of old trees which have always been in sod and whose roots are very close to the surface. Borers and other difficulties may be expected to be more serious in mulched than in tilled orchards. Since quince orchards cannot be pastured, because the trees are too low, it follows that the only rational treatment is clean culture.

Propagation.—Upon light soils the quince is generally readily propagated by cuttings of the hard wood. These cuttings are taken in the fall or winter, the same as those of currants or grapes, and they are cut from 10 to 16 inches long. They should be stored for a couple of months or more in moist sand, moss or sawdust, or buried in a sandy place beyond reach of heavy frost, in order that they may callus, inasmuch as this process facilitates their growth when they are planted in the open ground in the spring. In heavy lands, cuttings are not often reliable, and resort is then had to mound-layering or "stooling," and to grafting on bits of apple roots, and to budding on quince stocks. These three methods are common in western New York. A "stool" is a plant which has been kept very low, the top being continually cut back, so that many suckers spring from the crown each year. A mound of earth about the suckers causes them to send out roots, so that they can be removed at the end of the first or second year and they are then treated as independent plants. If apple roots are used, the quince cions are worked on them in the winter time, as in ordinary root grafting. The union with the apple is weak, but it is sufficient to afford support to the cion for a season or two, until roots strike from the quince itself. The plant is usually taken up the first fall and the apple root is cut off, otherwise troublesome apple suckers may arise. The quince cion should have thrown out roots by this time, and it is set in the nursery row again to shift for itself. Perhaps budding upon the quince itself is the method in most common use where propagation by cuttings is not practicable. The stock in this case is the Angers quince, which is imported from Europe and which is the same as that used for dwarf pear stocks. Quinces are set when two and three years old from the cutting or bud, but the latter age seems to be generally preferred.

Planting and pruning.—I am convinced that the ideal distance apart for planting quinces is about fifteen feet each way, although most orchards are closer than this. Some of them are even as close as ten feet each way. Too close setting requires heavier fertilizing and better care than most growers are willing to give, it demands severe heading-in, and it seriously interferes with spraying—a practice which can no longer be omitted in this state. The top should be started low, never more than twelve to twenty inches above the ground, I think; and the branches should be allowed to spread widely. The frontispiece (Fig. 1) shows what most New York horticulturists would regard as a model shape for starting the top of quince trees, although there is room for difference of opinion as to the advisability of such severe heading-in each year as this orchard has received. I have already discussed what I believe to be the fundamental necessities for the heading-in of the annual growth of peaches (in Bulletin 74), and the same observation may be applied to quinces: if bearing trees persist in making a heavy growth—say 18 to 30 inches—they should be shortened-in each winter; but if the land and treatment are such that the tree makes a rather slow hard growth, the operation will not be necessary. Under conditions of rapid growth, heading-in certainly induces fruitfulness, and it also keeps the tree within bounds. The real question at issue, however, lies farther back.

Is it wise to induce very strong growth in any bearing tree? Or, is it not better to use rather more potassic and phosphoric fertilizers and rather less stable manures and to be more conservative of late cultivation? These are questions which the grower must answer for himself, for everything depends upon the original character of the soil.* It will generally be found, I think, that some heading-in of quince trees is desirable, especially when the orchard is young. The Maxwell orchard, shown in the frontispiece and which has been fertilized chiefly with stable manure, has probably been the most uniformly successful of any in the state, and a half or two-thirds the annual growth has been cut away each winter; but this does not prove that the same result may not have been accomplished more economically. Shortening-in the annual growth also thins the fruit, for it cuts off all the terminal bloom: the crop, in such cases, is borne upon the tips of the side spurs, and it is less liable, perhaps, to injury from winds.

The crop, and marketing.—If the quince tree is three years old when set—which seems to be the age of tree generally preferred—it should bear a few quinces the second or third year, and from that time the crop should increase each year until its full capacity is reached—a period which comes when the tree is nine or ten years planted. If the orchard is well cared for, it should continue to be profitable for thirty or forty years, and perhaps even longer. If the trees are ten by fifteen feet apart, so that about 300 trees stand upon an acre, an average crop for an orchard in full bearing should be a bushel to the tree of marketable fruit, and in occasional years this crop may be doubled.

Although the quince is not a dessert fruit, the prices are determined very largely by the manner in which the crop is packed and handled. A bruise soon becomes a dark brown spot and detracts greatly from the appearance of the product. The fuzz is commonly rubbed off completely to bring out the orange-like color and surface of the fruit. The Maxwells, at Geneva, make three grades of quinces, aside from the culls, but the latter are usually very few. The best grades and the earlier pickings are shipped in fifteen-pound or peck grape-baskets or in bushel kegs, whilst the main grade is marketed in barrels or half-barrels. The profits ordinarily lie in the two top grades. Prices of quinces vary greatly. This year, most shipments brought poor returns, although the later ones were fairly remunerative, bringing from $2.00 to $2.50 per barrel. The quince barrel used in western New York is the so called pony barrel, holding less than three bushels. The quality of quinces was low this year. The fruit did not keep long and it had a decided tendency to crack. The former condition was probably due to premature ripening as a result of the prolonged drought, and the cracking was evidently the result of the fall rains in swelling out the fruit. It is noticeable that the placing of each individual fruit by hand in the small packages, brings fully as good returns as it does in peaches and other desert fruits, and this is a sufficient answer to those persons who say that because the quince is not consumed raw therefore it is not worth while to "fuss with the packing."

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* See Bulletin 72, upon "The Cultivation of Orchards."

Varieties.—The varieties of quince are few, and yet not more than half of them are known in western New York. The only variety which is generally esteemed is the Orange or Apple, which is uniformly reliable and productive, and, being of mid-season, may be used either for early or late market. The variety is not uniform, however. There are various more or less distinct but unnamed strains of it. It tends strongly to reproduce itself from seeds, as I have proved by experiment. While the Orange quince should comprise far the greater part of every commercial quince plantation in this state, I am convinced that a few trees of an earlier variety, like the Rea, and of a later variety, like the Champion, will be found to be desirable. The only varieties which compete for favor in this state appear to be four, the Orange, Champion, Rea, and Meech. Other varieties, of which about a half-dozen have been prominently mentioned, are not yet sufficiently tested to allow of an intelligent report.

Our own quince plantation was set in the spring of 1889, and it comprises, chiefly, the four varieties mentioned above. The first fruits were borne in 1891. Taking the productiveness of the Orange quince per tree as 10 as a basis of comparison, the yields for the various years stand as follows :

	Orange	Champion	Rea	Meech
1892	10	12	2	5
1893	10	8	2	4
1894	10	16	7	8
Average	10	12	3⅔	5⅔

It will be seen, that, so far, the Champion has been most productive and the Rea least productive, while Meech has been about half as productive as Orange. In 1894, the Champion bore over a half bushel to the tree; and this quantity may be taken as a fair crop for trees of this age. From this time on the yield should gradually increase in quantity and uniformity. The following notes of these varieties, as grown in the University gardens, may be of interest:

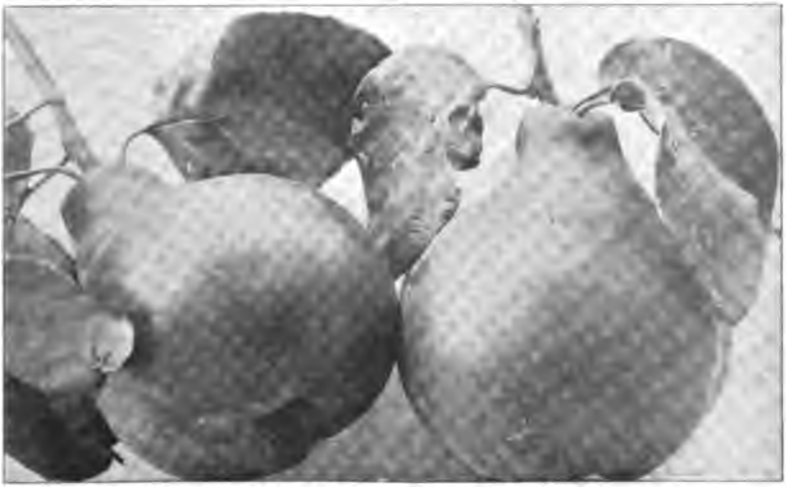
3.—*Champion. ½ nat. size.*

Orange or Apple Quince (Figs. 7 and 8).—Tree of moderately vigorous and spreading growth. Fruit very variable in size and shape, but in the ideal or original form not at all pear-shaped but distinctly flattened on the ends, like an apple. Color bright pale orange, the surface only moderately fuzzy. Midseason, and keeping until February under good conditions.

The great variation in the shape and color of the Orange quince is generally thought to be due to the existence of sub-varieties which have arisen independently from seed, and this is undoubtedly the occasion of most of the differences; but Fig. 8, which is explained on page 622, shows that it may sometimes arise from the treatment given the trees.

The old Orange or Apple quince was of European origin, but it is doubtful if the original strain or type is now in cultivation in this country.

Champion (Fig. 3).—Tree an upright grower, taller than the Orange. Fruit large, distinctly pear-form, furrowed about the top, generally remaining greenish-yellow upon the tree, conspicuously covered with a floccose wool or fuzz. Late; in some places it does not ripen well. It is the best keeper which I know. In a comparative keeping test of the four varieties here considered, which was made in an ordinary cellar, the Champion did not begin to get soft and yellow until the middle of January, while the other varieties were at that time showing signs of failing.

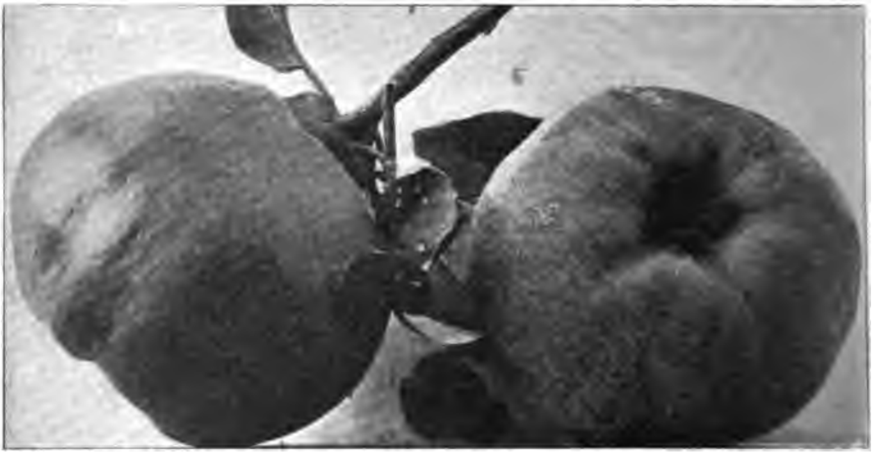


4.—*Rea* (*Rea's Mammoth*). ½ *nat size.*

The Champion is an American quince of recent origin.

Rea, or Rea's Mammoth (Fig. 4).—Tree small, not over two-thirds the size of the Orange at the same age. Fruit large to very large, mostly abruptly pear-form, rich orange in color, the surface very smooth, flesh of excellent quality. Ripens early, and does not keep so long as the Orange.

The Rea is a seedling, raised some thirty years or more ago, by Joseph Rea, Coxsackie, N. Y. The variety is either greatly modified by the conditions under which it grows, or else it is mixed. It was first described as a vigorous grower, with apple-shaped fruit, but our trees—procured from a reliable source—contradict both these characters. As we have it, it is at once distinguished by the short stature of the tree, and the large size, deep color and smooth surface of the fruit. It is not productive, but the excellent quality of the fruit and its showy size and color, make it worth growing to a small extent for early or fancy markets. It undoubtedly needs high culture.



5.—*Meech* (*Meech's Prolific*). *½ nat. size.*

Meech, Meech's Prolific (Fig. 5).—Tree very like the Orange, but lower. Fruit ranging from nearly apple-shaped to short pear-shaped, somewhat furrowed at the top, covered with a thin fuzz, color of the Orange quince Keeps about as long as the Orange.

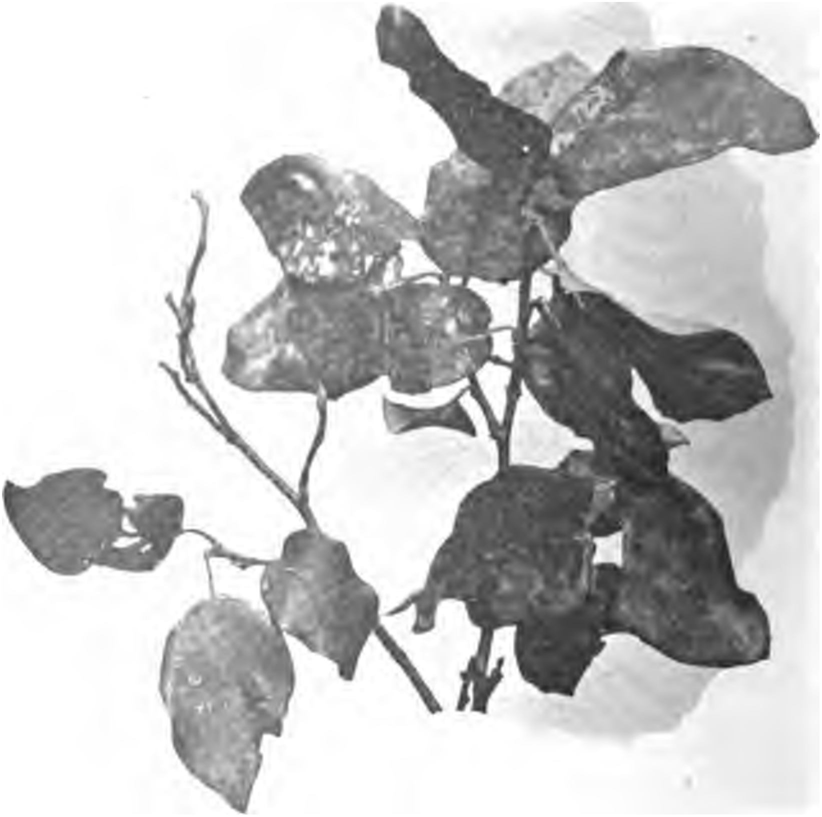
The Meech is supposed to have originated in Connecticut some thirty-five years ago. It was first described and named in 1883 by W. W. Meech, author of *Quince Culture*, as Pear-Shaped Orange quince. It was subsequently named for Mr. Meech, who brought it into notice. It is said to be the most productive of all varieties, and this was the reason for its introduction; but with us thus far, it is not only comparatively unproductive, but the fruits have always been very variable in size and they have been particularly subject to the black-spot. I am hoping that as our trees become older, the variety may sustain its advertized reputation.

The Chinese or Hong Kong quince, which now and then appears in catalogues, represents a wholly distinct species from our ordinary quinces (it is *Pyrus Cathayensis* of botanists), and it is a very distinct and unique fruit, and the tree is wholly unlike an ordinary quince tree. It is not hardy in the northernmost states, although it was fruited in Weschester County, New York, so long ago as 1845. The fruit is oblong and very large, often weighing over two pounds.

Two of the newer quinces of which I have seen fruit and which are promising, are the Johnson and Bourgeat. The Johnson is a mild or sweet apple-shaped quince of the season of the Orange, or a little later. It originated with W. B. K. Johnson, Allentown, Penn. It promises well for home use. The Bourgeat is a variety recently imported from France. It is a firm apple-shaped quince of medium or large size, ripening just after the Orange.

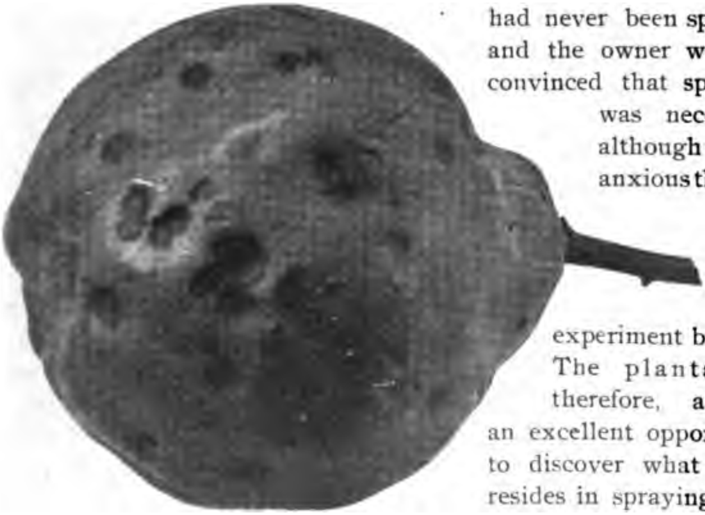
Leaf-blight and fruit-spot.—The quince falls an easy prey to various insects and fungi, although there are only three of the insects and two of the fungous diseases which are serious, in this state, so far as I know. The one most serious and wide-spread perplexity is the fungus (*Entomosporium maculatum*) which spots the leaves (Fig. 6) and causes them to fall early, and produces the black-spot of the fruit (Fig. 7). This disease is probably always present upon quince trees, although it may not always produce serious difficulty. It is undoubtedly most serious in its effects upon orchards in sod, or those which are otherwise neglected. Yet every orchard is liable to be ravaged by the fungus. In most orchards the leaves begin to fall more or less in August and early September from the effect of the disease, and it is not infrequent to see plantations almost entirely defoliated while the fruit is not yet fully grown. In perfectly healthy trees, the foliage should persist until after the fruit is harvested. The loss of the foliage deprives the fruits of nourishment when they are completing their growth, and they usually remain small, and immature;

and it also prevents the tree from laying by that store of energy which is needful for next year's crop. I have often known the attack to come on so early in the season that the fruit appears to become stunted even before it is half grown. But the disease is serious upon the fruit itself, as well as upon the leaves. In well tilled plantations, its usual appearance is that shown in Fig. 7; but in serious attacks the fruit cracks or becomes lop-sided, the same as pears do when attacked by the same fungus.



6 —*The leaf-blight. The left hand specimen was not sprayed; the other was.*

Happily, this fungus is readily held at bay by energetic spraying with Bordeaux mixture. This has been proved time and again by various experimenters, but in order to bring the subject home by a test upon a commercial scale amongst our fruit-growers themselves, I this year selected the orchard of Col. H. Bowen, at Medina, in Orleans county, for experiment. This is an orchard in full bearing, comprising Orange quinces, but which has been in sod for several years. The trees are healthy, but moss-grown, and the crops have been indifferent because the fruit is usually small and more or less scabby and it has not been abundant. The orchard had never been sprayed, and the owner was not convinced that spraying was necessary, although he was anxious that the experiment be tried. The plantation, therefore, afforded an excellent opportunity to discover what value resides in spraying, inasmuch as there was no fertilizing, tillage, or other circumstance to complicate the result.*



7.—*Black-spot of the Quince (natural size).*

It was very late in the season (June 25) when the first application was made, for at that time the fruits were as large as the end of one's thumb—an inch long—and the leaves were already badly marked with the small brown spots of the leaf-blight. In fact, I thought that it was too late to obtain any results from the spray. Yet the Bordeaux mixture (6 lbs. sulphate copper, 4 lbs. lime, 40 gallons water) was "put on to kill," as a spectator remarked. The trees were soused with the mixture, and the entire foliage and the limbs were deep blue as soon as the application had dried. On the 9th of July, the application was repeated. At this time, the first application appeared to have done no good. The foliage was equally blighted in the sprayed and unsprayed portions, so far as I could determine, although the disease did not appear to have progressed much in the meantime. The fruits upon the sprayed portions were much browned and discolored by the Bordeaux. The experiment seemed to be unpromising, and it was not carried further.

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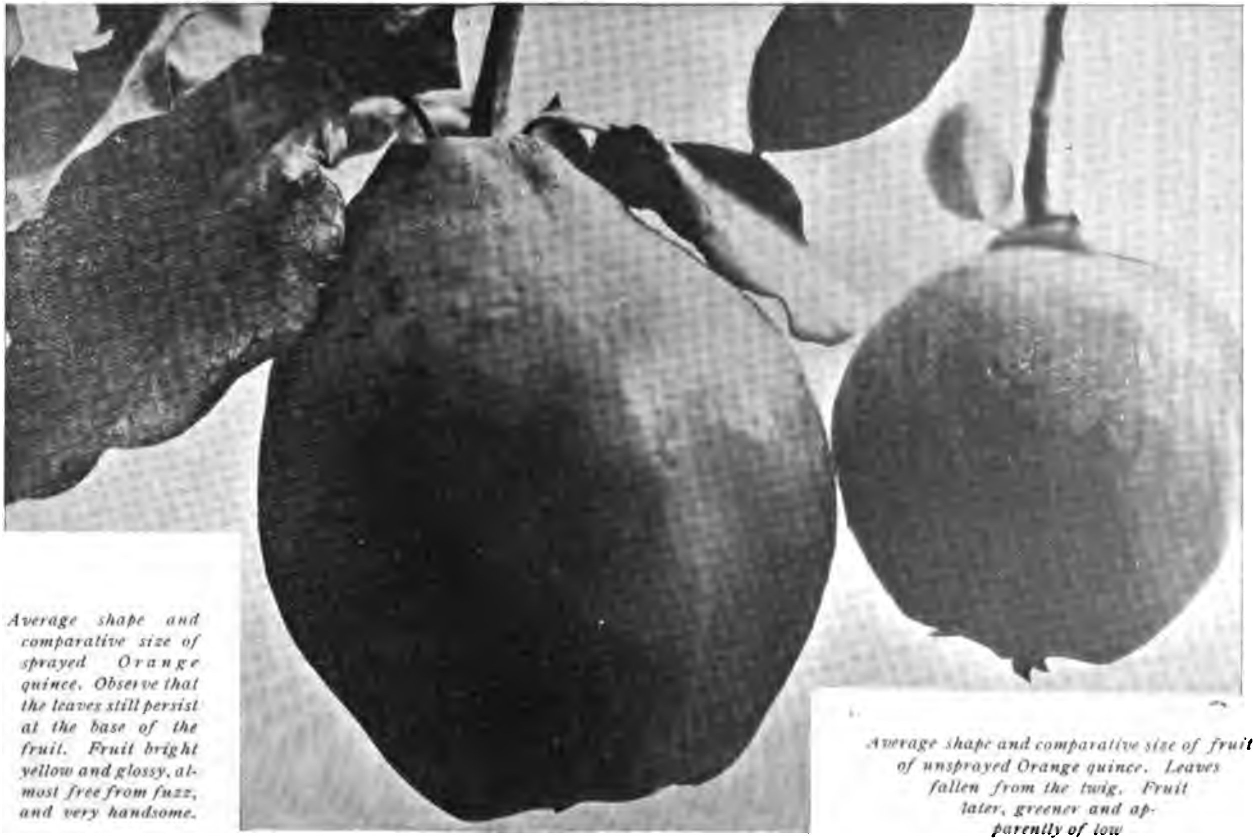
* The spraying experiments made upon quinces in the University gardens will be reported on in a later bulletin.

On September 21st, the orchard was visited again, and the treatment was found to have brought the most remarkable results! The fruits upon the sprayed rows were nearly twice larger than upon the untreated rows alongside, yellower and less fuzzy, and they were markedly longer in form as well as much more uniform in size. The russet discoloration of the Bordeaux mixture had wholly disappeared. Fig. 8 shows an average quince from each lot, three-fourths natural size. The differences of shape are quite as marked as those of size. While I am unable to account for this change of shape, it was easy enough to see that the increased size was due to the persistence of the leaves upon the sprayed trees. From one-fourth to one-half the entire foliage had fallen from the unsprayed trees, and what leaves remained were small and yellow. On the sprayed trees, however, the leaves were all intact and they were large and dark green. It was noticeable that the tips of the shoots on the untreated trees were almost uniformly bare of leaves, and the leaves which stand directly against the base of the fruit had fallen. Fig. 6 shows two characteristic twigs, the short one upon the left being from an unsprayed tree, the other from a sprayed tree. The leaves upon the shorter twig show the spots of leaf-blight. Fig. 8 shows how the leaves persist next the fruit upon the sprayed specimens, while they fall from other fruits. These leaves must exercise an important office in the growth of the contiguous fruit, for the quince has no stem in the sense in which apples, pears and plums have, but the leafy branch terminates directly in the fruit. I am not sure that I understand why the sprayed quinces were so much less fuzzy than the others,

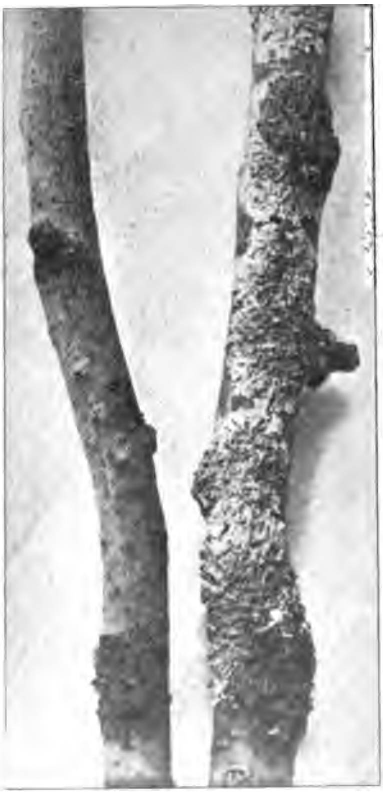


Average shape and comparative size of sprayed Orange quince. Observe that the leaves still persist at the base of the fruit. Fruit bright yellow and glossy, almost free from fuzz, and very handsome.

Average shape and comparative size of fruit of unsprayed Orange quince. Leaves fallen from the twig. Fruit later, greener and apparently of low quality.

8.—*Quinces from adjacent sprayed and unsprayed trees. ¾ nat. size.*

but I am inclined to think that this woolly covering—which is a living growth from the surface of the fruit—was killed by the Bordeaux mixture. The young fruits, it will be remembered, were much discolored by the Bordeaux, but the absence of any roughness or discoloration upon the ripe fruit apparently shows that the injury did not extend deeper than the fuzz. These sprayed fruits were not only larger, yellower and smoother than the others, but they were almost wholly free from spots or cracks of the spot fungus, although none of the fruits in the orchard were seriously attacked. Another marked result of these two sprayings was the complete destruction of the "moss" which had overgrown many of the trees. Fig. 9 shows on the left a branch from a sprayed tree. This was completely covered with the moss when the experiment began, but this moss was killed by the sprays and nearly all of it had fallen off when the trees were examined in September. The branch upon the right shows the moss upon the unsprayed trees.*



9.—*Sprayed limb (on the left) with "moss" or lichen destroyed; unsprayed limb on the right.*

The results of these two tardy spayings, then, were exceedingly satisfactory. In fact, the outcome was more marked than is usually the case, and I should not expect it again even in this same orchard. The plantation had been so completely uncared for in respect to such treatment and to tillage, that it was in just the condition to show unequivocally any advantage which had been gained by the spray. Yet marked results in combatting the leaf-blight are so certain, that nearly all the best quince growers in western New York spray their orchards. The experience in this orchard proves that the spread of the disease may be almost wholly stopped even after the leaves are conspicuously marked by it. The disease cannot be said to be cured in the sprayed leaves, but the fungus is no doubt kept from fruiting and it is confined largely to its original points of attack ; and it is not allowed to spread onto the new leaves. It is unwise, of course, to wait until the disease appears before applying the spray. An application of Bordeaux should be made soon after the blossoms fall, and two or three thereafter at intervals of two or three weeks, for the disease may always be expected. Col. Bowen makes the following statements concerning the experiment in his orchard :

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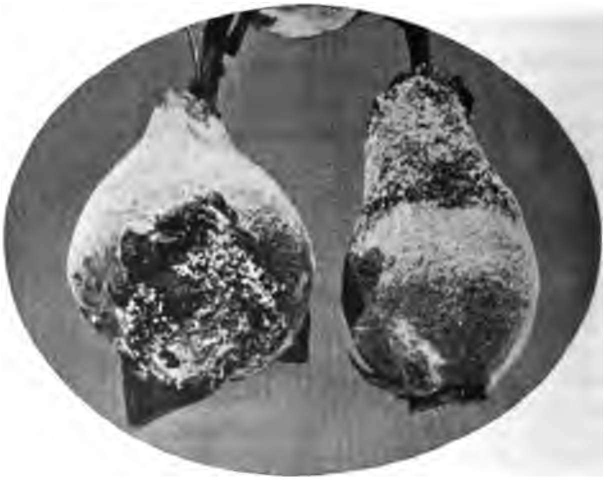
* This "moss" is really a lichen. Two species are growing upon the right hand branch. The most abundant light-colored one is *Physcia stellaris;* the dark patches are *Theloschistes concolor.* These were determined by Miss Clara E. Cummings, of Wellesley College.

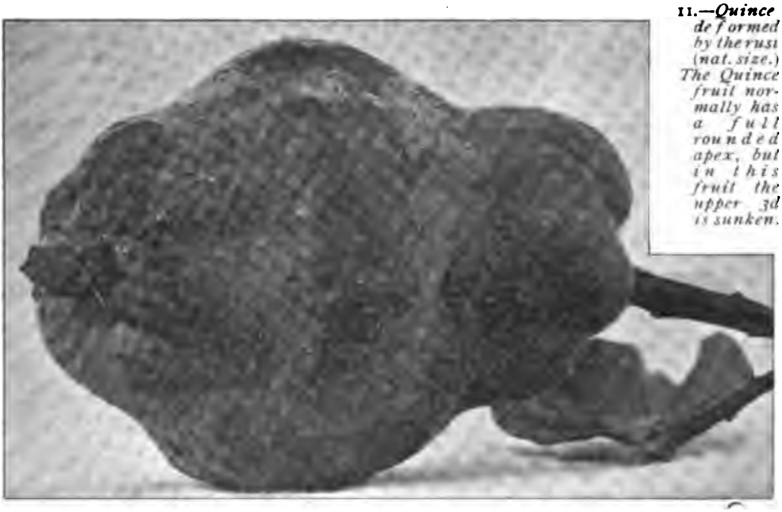
> I consider the experiment in my quince orchard really marvelous, as do other fruit growers—some of whom visited it several times during the summer and also at picking time. The fruit on the rows of trees sprayed was quite perfect, being as a rule free from black specks, and of extraordinary size, some weighing a pound each, and one barrel containing less than 200 quinces sold in Albany for $6.00, when ordinary fruit was selling for less than half that price. The foliage on the sprayed trees remained on long after the others had fallen. The spray also killed the moss, and the prevalence of red rust was not as great as on the trees not sprayed. Your experiment here will have the effect, I think, to arouse fruit growers to renewed activity next spring in caring for their fruit orchards of every description.
>
> H Bowen

Rust.—Another disease which is nearly always present to a limited extent, and which has attracted much attention during the past season, is the rust. It is well shown in Fig. 10. It is very conspicuous upon the fruit, as it covers the injured portion of the quince with an orange fringe-like growth. The tube-like projections of the fungus contain numerous spores, and when this stage is apparent the fruit is already irrevocably ruined. Sometimes the entire young fruit is involved, and it may die and fall; but more often the fruit hangs upon the tree and the diseased portion becomes dry, hard, black and sunken. Such a fruit, with the entire top third deformed by rust, is shown in Fig. 11. This rust fungus also penetrates the twigs, and often causes knots to appear, resembling the black knot of the plum (Fig. 12). This fungus has a curious life history. Upon the quince, and some related fruits, it is known as *Roestelia aurantiaca*, but it is really only a form of another and very different looking fungus which causes apple-like swellings upon the twigs of red cedar trees and juniper bushes. Upon these plants the fungus is known as *Gymnosporangium clavipes*. This cedar fungus, or so-called cedar-apple, produces its spores in spring, and these are carried by the wind, and, alighting upon the quince, soon produce the rust; and when this rust upon the quince first attracts attention, it is already beyond control, as I have said, save by removing and burning the diseased parts. The spores produced by the quince rust are incapable, so far as known, of again producing the rust, but they are scattered by the wind and when they come upon the cedar or juniper produce the cedar apple stage. It has been



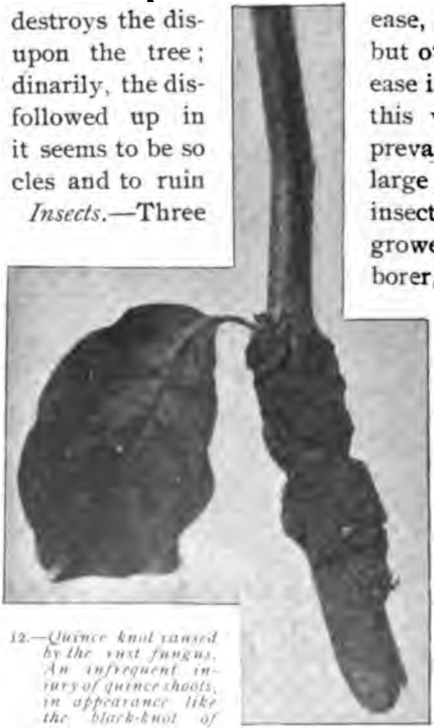
10.—*Rusted young quinces. The left hand specimen is attacked at the blossom end and the other at the stem end.*

proved that cedars may affect quinces, or other amenable plants, at a distance of eight miles. Evidently, the first thing to be done is to destroy the cedar trees, if rust is feared. The next thing to do is to destroy all affected portions of quinces, hawthorns, apples and other plants upon which the rust stage appears. There is some question as to how long the fungus persists in the quince wood. It has been thought that the mycelium or vegetative portion is perennial in the tissues of its host, but this is doubtful. I believe that the rust can be kept off the quince by thorough spraying with Bordeaux mixture. The disease was certainly less prevalent in the sprayed portion of Col. Bowen's orchard than in the unsprayed part. If the leaves, fruits and twigs of the quince tree are covered with the fungicide, the spores will find small chance of making successful germination when they arrive from the cedar trees. But this rust is rarely very serious, and if the grower has sprayed dutifully for the leaf-blight, he will have little to fear.



11.—*Quince deformed by the rust (nat. size.) The Quince fruit normally has a full rounded apex, but in this fruit the upper 3d is sunken.*

Pear-blight or fire-blight is undoubtedly the most serious disease with which the quince grower has to contend. It is the same disease which is so destructive to pear orchards in certain years, and which attacks various sorts of apples, particularly the crabs. This is known from all other diseases by the death of the entire shoot or branch, and the uniform browning and dying of all the leaves involved. In the true fungous diseases, as the leaf-blight already described, the leaves become spotted and they eventually turn yellow and fall; but in this fire-blight the leaves are uniformly dead brown throughout, and they wither and hang upon the limb. The bark of the diseased branches becomes hard, dry and shrunken. Unfortunately, there is no remedy for this disease, save to cut off the affected parts and burn them. This treatment destroys the disease, for it is local in its destruction upon the tree; but other attacks may occur. Ordinarily, the disease is not serious if it is carefully followed up in this way, but in occasional years it seems to be so prevalent as to overcome all obstacles and to ruin large blocks in the orchard.



12.—*Quince knot caused by the rust fungus. An infrequent injury of quince shoots, in appearance like the black-knot of plums.*

Insects.—Three insects are troublesome to quince growers in western New York, the borer, codlin moth, and quince curculio. These are well known invaders and it is not necessary to make any lengthy account of them here. The borer,—which is particularly partial to the quince—should be dug out. If the trunks and crowns are examined in May or June and again in September or October of each year, all serious trouble may be averted. It is doubtful if the many strong smelling and caustic washes which are recommended are really efficient. Some growers recommend tarred paper tied tightly about the crowns of the trees for the purpose of keeping away the borers*. The following experience however, given me by F. H. Wakeley, Greenville, Green Co., N. Y., makes me cautious about advising its use:

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* Serious results often follow the use of tarred paper tied about trees, for the bark is likely to die underneath the paper. This is especially true if the paper is left on during the growing season, and the trouble seems to be

"Twelve years ago, I set three hundred apple trees and the mice and borers went for them till I was about discouraged. So one November I wrapped about one hundred trees with tarred building paper. Some were small trees, set about one or two years before, others were two to three inches through. Next June I noticed that one of the young trees was failing and I found the bark dead as far as the paper touched it. I stripped the rest of the trees quickly. Trees the size of my thumb were all killed, while in the larger ones the outside bark turned black and peeled off. If I had left it on through the summer I think it would have killed every one. I have tried soap, ashes, etc., with poor success. I know of one orchard that is wrapped with pieces of wire screen such as is used for windows, and it appears to fill the bill. I shall try it when I set more apples."

The codlin moth is the same insect which delights in the apple. It is less serious in the quince. The best remedy is to add Paris green to the Bordeaux mixture which is applied for the leaf-blight. The poison should be added to the Bordeaux mixture in the same proportion as if the latter were water; that is, one pound of Paris green is added to 250 gallons of the mixture.

The quince curculio is closely allied to the plum or peach curculio. It punctures the fruit and causes it to become rough and knotty. The Maxwell's, with whom it is very bad, have tried to dislodge it with Paris green, but with little success. The best method is undoubtedly to catch the insects upon sheets in the same manner as the plum curculio is captured. Certainly, one is sure of the bug when he gets him between his fingers.

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greatest upon young trees. It is possible that different brands or grades of tarred paper behave differently in the effect upon the bark. In Bulletin 69, p. 254, I said that tarred paper may be used to keep mice away from trees, but I recommended that it be "rolled lightly about the base of the tree," not tied; and inasmuch as mice are never troublesome in warm weather, it is presumed that the paper will be removed in early spring. But even with these precautions. it may not be wise to use the material unless the grower has had some experience with

REVIEW.

Quince growing is an important interest in western New York, where it has no doubt reached its largest dimensions in North America.

As a rule, quinces bring only ordinary profits, owing to the limited demand for the fruit, but this difficulty may be in a measure overcome by searching out distant or unsupplied markets.

The crop is reliable ; that is, it is not easily destroyed by capricious variations in weather, the trees are hardy and productive, they are easy to prune and spray, and the diseases and insects, while rather numerous, are held in check with comparative ease, with the single exception of the pear-blight.

The best soils for quinces in western New York, are thought to be the heavy clay loams. The lands should be retentive of moisture, but not wet and soggy. Good drainage is essential to quince culture, as it is to the growing of pears or other fruits. See page 610.

So far as known, the general plan of fertilizing quince orchards should be that which is also best adapted to apples and pears,—the free use of potash and phosphoric acid, and the conservative use of nitrogen. It is probable that, upon good quince lands, most or all the necessary nitrogen can be obtained by tillage and cover crops. See page 610.

Quince orchards should be given clean culture. The best results cannot be expected if they are kept in sod. The roots are usually shallow, however, especially if the land has not been cultivated from the first, and very shallow tillage is generally best. It is sometimes impossible to plow up old soddy orchards, and in this case the fertilizers may be sown upon the sod, and the land can be subdued by dragging or cultivating lightly when the sod is soft in spring. See page 612.

Probably the best results will be obtained, in the long run, if the trees are set fourteen or fifteen feet apart each way, although they are commonly planted closer than this.

The quince tree should have a trunk twenty inches or less high. The pruning is essentially the same as that demanded by the apple, except that it is generally found to be advisable to shorten-in the annual growth somewhat each winter. Whether this shortening-in shall be practiced, as well as the extent to which it shall be carried, depends almost entirely upon the growth which the tree is making. See pages 611 and 613.

The first fruits of consequence may be expected when the tree is three or four years planted, although the quince does not arrive at full productiveness until it is nine or ten or more years old. An average crop for an orchard in full bearing is one bushel of first-class fruit to the tree, but this yield is exceeded in some years. Careful attention to handling and marketing pays as well with the quince as with other fruits. Shiftless men are never successful fruit growers.

The Orange or Apple quince is the only variety which is commonly planted. The Champion is a better keeper and equally productive, but it is too late for some localities. Rea is an early variety of large size, but the tree is small in stature and it is not very productive. See pages 615 to 619.

The fungus which causes the blight and falling of the leaves (Fig. 6) and the spotting and cracking of the fruit (Fig. 7) is the commonest enemy of quinces in this state; but it is readily held in check by spraying with Bordeaux mixture. See page 619 to 625.

The rust is a curious disease which is always fatal to the fruits which it attacks (Figs. 10-12), but which is rarely seriously prevalent. One stage of the fungus which causes it occurs upon red cedars and junipers, and the destruction of these plants is the first means of prevention. All attacked quince fruits and twigs should be burned. It is probable that the thorough spray of Bordeaux mixture which destroys the leaf-blight will also prevent the rust fungus from obtaining a foot-hold.

Pear-blight is the most serious disease of quince trees, and there is no way of keeping it in check but to cut off and burn all affected limbs. See page 627.

Three insects are mischievous in western New York quince orchards: the borer—search for it twice a year; the codlin moth—put Paris green in the Bordeaux mixture; and the quince curculio—jar it onto sheets, as you would the plum curculio.

L. H. BAILEY.

Bulletin 81. **December, 1894.**

Cornell University Agricultural Experiment Station.

HORTICULTURAL DIVISION.

BLACK-KNOT

OF

Plums and Cherries, and Methods of Treatment.

By E. G. LODEMAN.

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62. The Japanese Plums in North America.
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66. Test of Cream Separators
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf-Blight of the Strawberry.
80. The Quince in Western New York.
81. Black-Knot of Plums and Cherries, and Methods of Treatment.

CORNELL UNIVERSITY, ITHACA, N. Y., December 15, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY,

Sir:—The following account of the black-knot of plums and cherries is submitted for publication and distribution under section 87, chapter 675, of the laws of 1894. The subject is an important one to all fruit growers, and the present account contains the first experimental proof that the disease can be kept in check by spraying. The leading points established in this paper are these: The disease usually shows itself the year following inoculation, a fact which is proved by the absence of knots on the growth of the season; the inoculation occurs mostly in crotches and at the junctures of the annual growths, owing to the greater frequency of chinks at these places, and to more tender bark, and to convenient places for lodgement of the spores; if the branches are constantly covered with fungicide, the germinating spores are killed. Good Bordeaux mixture remains upon the branches a long time, and it appears to retain its efficacy from the fact that when applications ceased early in June the summer spores of the fungus, which no doubt appeared after this time, were apparently unable to seriously multiply the disease. Whilst the results with the spray are surprising, there is nevertheless every reason for anticipating them, for it is evident that the infection takes place from spores falling upon the plant, and it is generally understood that germinating spores are killed by copper fungicides. Mr. Lodeman's results with the black-knot are supplemented by similar results obtained by myself upon another fungus which enters the deep tissues, the red rust of the quince (see Bulletin 80). L. H. BAILEY.

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1894. Lodeman. Garden and Forest, No. 356, p. 508.

THE BLACK-KNOT OF PLUMS AND CHERRIES, AND METHODS OF TREATMENT.

Distribution—Many of our stone fruits, both the wild and the cultivated forms, suffer from the attacks of a disease which is popularly known as the black-knot. It is of American origin, and from the early records of its presence on cultivated trees, it appears to have been particularly abundant along the northern half of our Atlantic sea-board. This may be ascribed to the fact that this portion of the country was first most thickly settled and consequently such a trouble would there be first noted. In the early part of this century, however, the disease had become more serious in most of the regions in which it was first mentioned, and the ruinous effects of its presence gradually became known in those sections which appear to have been free from the trouble at the time the first settlements were made. It is not improbable that the disease was first restricted to the country east of the Alleghany mountains, although several of the plants upon which it is found are native in the regions to the west. It appears that no serious damage was done by the fungus in western orchards until the number of its cultivated host plants had become sufficiently great to allow of the rapid propagation and spread of the disease. In some cases its presence could be traced directly to an eastern source.

In *The Cultivator*, for 1850, page 333, is the note that "Benjamin Hodge, of Buffalo, N. Y., who has raised and sold trees for the past 30 years says he never had this malady among his plum trees till the present season, and that in the instance cited it was introduced from the east." He further claimed that all the affected trees came from stocks brought from Massachusetts. In 1879 the statement was made* that the knots were appearing about Cincinnati in regions which had previously been free from the disease. Other cases of a similar nature might be mentioned, and although the disease may have been native to a large area, it appears to have attracted attention only after the cultivated plants upon which it thrives had been generally grown, and the conditions for its rapid dissemination had become favorable. At present the disease is confined to North America, no case of its occurrence in Europe or foreign countries having been reported. It is found throughout the United States, but is rare in the extreme south.

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* *The Country Gentleman*, vol. 44, p. 262.

Description.—The superficial characters of the parts attacked by this disease are familiar to nearly every one who is in any degree interested in the extermination of the pest. The term "black knot" is very expressive, for the affected parts swell and present the form of more or less elongated knots which turn a deep black during the fall and winter. According to Humphrey* the newly forming knot can often be seen in the fall. It then appears "as a slight swelling of the branch, arising near an old knot, or independently." It is generally in the spring, however, that the knots can first be plainly seen. Affected portions commence to swell as soon as the active flow of sap begins, and as the swelling increases the bark is ruptured and a granular growth soon fills the crevices. This newly formed substance is light yellowish brown in color, and a tinge of green can sometimes be seen. The brown shade deepens as the season advances. During the latter part of May and early in June the swellings have enlarged to such an extent that they are frequently three to four times the diameter of the twigs upon which they are found. The bark very soon disappears, and the knot is found to be composed of a mass "in which all distinction between wood and bark has been lost. In the knot we find bast fibres, wood cells, and dotted ducts; but the prevailing tissue consists of a collection of dotted, rectangular, parenchymatous cells, with very thick walls which closely resemble the walls of the medullary rays."† The knot also gradually changes color; and eventually it is perfectly black and presents the appearance which is so commonly seen, Figs. 3 and 4.

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*Eighth Annual Report of the Mass. State Agric. Exp. Station, p. 205.

†Farlow, Bull. of the Bussey Institution, Harvard University. Part V. p. 446.

There is much variation in the size, shape, and location of the knots. Sometimes they do not grow to be more than a quarter of an inch in length, and then they do no particular damage. Such small knots are seldom seen, for their growth in spring is generally quite rapid and they frequently extend several inches along a twig. The largest knot which has come to my notice was on Morello cherries and was nearly five inches in length, it being all one year's growth. If the growth of other years is considered, the diseased portion will be considerably extended. It is a peculiar circumstance that the knots as a rule do not encircle a branch, but nearly all extend along the branch upon one side while the portion opposite remains healthy and permits the passage of the sap to the living portions beyond. Small twigs are frequently killed outright, for in them the disease soon cuts off all communication between the parts above and those below the affected portion. Large limbs do not succumb so rapidly. The disease gradually extends from year to year and it may be a long time before the death of the parts beyond takes place, for such, with probably rare exceptions, is the result which eventually follows the appearance of the trouble.

The form of the knots varies considerably. Upon the smaller branches, those two or three years of age, they are generally straight, or nearly so. The swelling is often more marked at the center of the diseased portion, and gradually diminishes towards the ends; but the swelling may have nearly the same diameter throughout its length, and in such cases the knot terminates abruptly. If the twigs are but a year or two old the presence of the knot may cause considerable bending of the wood, so that frequently the knot turns at a sharp angle, or it may be inclined to the form of a spiral. Large branches which cannot be affected in this manner generally cause the formation of knots that are more or less oval in outline, the most protruding portion being near the center. When the knots are formed in the forks of two branches, as so frequently occurs, they extend along both branches beyond the point of union, and also downwards. Such knots vary greatly in form.

The large majority of the knots found upon Morello cherries seem to form in the following places: in the crotches of younger limbs, at the union of the consecutive growths of two seasons, and upon small spurs which commonly bear the fruits. I have seen some the cases in which it appeared as if entrance had been gained in the axil of a leaf, or about the bud situated at its base. The swellings frequently form in the crotches of limbs that sometimes are four or five years old, but younger branches suffer to a very great extent. The knots which form at the union of the growth of different seasons may generally be found upon wood that is from one to three years of age. The center of the swelling is, as a rule, near the point of union. (See also page 646.) I have as yet failed to find in autumn or winter a well developed knot which was formed upon the growth made during the preceding spring and summer. They have invariably appeared upon older wood, and generally in the positions mentioned above. (See Fig. 3 page 645.)

During May and June the newly formed knots are covered with a velvety growth, but this soon disappears. The knot then becomes dark and by winter has become perfectly black. It is then covered by innumerable, smal .levations which project from its irregular granular surface. At this season the knot is generally hollowed out by insects which have developed within, and so there is often not much more than a mere crust remaining. During the fall and early winter many of the knots become more or less coated with a substance which is yellowish white, and other colors may also be seen. This appearance is not a development of the knots, but is caused by a fungus which is parasitic upon them.

Cause.—It is only in recent years that the true cause of the black knot has been demonstrated. Formerly the trouble was generally supposed to be due to the work of insects, and this opinion is still held by many, although scientists have shown plainly that insects are not responsible for such swellings. Other theories were also freely advanced, such as a diseased condition of the sap, abnormal condition of the plant's "constitution," the character of the soil in which the trees were growing, and some form of mechanical injury. But such ideas were not so commonly accepted.

Black knots are now known to be brought on by a fungus, *Plowrightia morbosa*. It was long suspected that such is the case, for the fungus was imperfectly described by Schweinitz as early as 1821.* But the first published statement that the black-knot is caused by a fungus appears to have been made by Dr. Joel Burnett, of Southboro, Mass., although no proof of the proposition was given.† It was based upon the fact that the curculio, which is a regular inhabitant of the knots, did not lay its egg in them until the latter had formed, and thus it could not be held as the cause of the first appearance of the swellings. It was not until 1876 that the relation between the knots and the fungus was clearly shown.‡ Dr. W. G. Farlow then removed all doubt as to the cause of the disease, and although the entire life history of the fungus is not described, no further question can be raised as to the origin of the trouble. The following plants also seem to suffer from this disease: Chickasaw plum (*Prunus angustifolia*), beach plum (*P. maritima*), native red or yellow plum (*P. Americana*), choke cherry (*P. Virginiana*), wild black cherry (*P. serotina*), wild red cherry (*P. Pennsylvanica*). The sweet cherries (*P. Avium*) are said to suffer occasionally, but no authenticated case seems to be on record.§

The life history of the fungus as now understood is in brief as follows:‖ The first external appearance of the disease is an enlargement which may be visible in autumn but is most marked in early spring. This swelling is caused by the irritation of the fungus which has entered the cambium layer of the branch. This layer is the one from which the inner bark and the wood are formed, and the presence of the fungus causes an abnormal growth to take place (see page 638). The first crop of spores are matured in May and June, and it is these and the threads bearing them which give to the knots the velvet coating they possess at this time of the year. The spores mature quickly and they are then scattered by various natural agencies. The knot then assumes a darker color and presents its characteristic hard, almost metallic appearance.

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* Synopsis Fungorum Carolinæ superioris, No. 134.

† *New England Farmer*, August 16, 1843.

‡ Harvard University Bulletin, Bussey Institution, Part V., 1876, p. 440.

§ I once collected knots from a tree of *Prunus Avium* in southern Delaware. The tree, which was of the mazzard or wilding type, was a foot or more in diameter of trunk, and the small limbs bore very numerous well developed knots.—L. H. BAILEY.

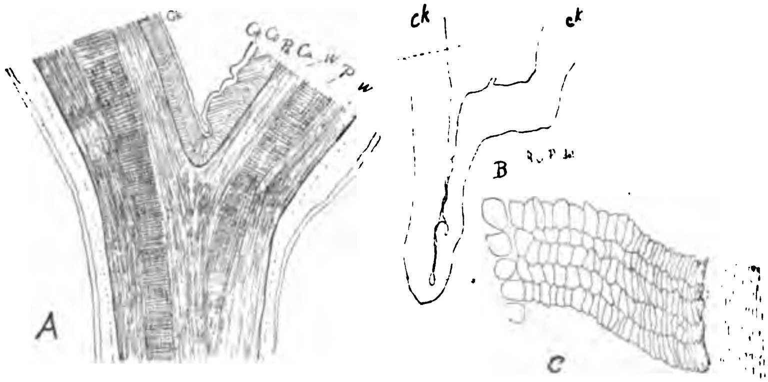
‖ A list of the most important papers relating to the black knot disease may be found on page 636.

Another crop of spores is still to be borne before the knot has finished its work. These spores are formed in the small pimple-shaped elevations which appear on the surface of the knots in autumn and winter. They mature during midwinter or early spring, the time appearing to vary in different localities. As soon as they have ripened they leave the minute elevations in which they were formed, and are scattered to propagate the parasite in some other spot. The central portion of the knot has then finished its round of existence, but the outer portions continue to grow and form new knots above and below the old one. In this manner a single knot may in time extend a long distance on a branch.

Many points regarding the development of the black knot fungus are still imperfectly known. Two of the more important of these are the time and the manner in which the spores succeed in gaining an entrance into the host plant.

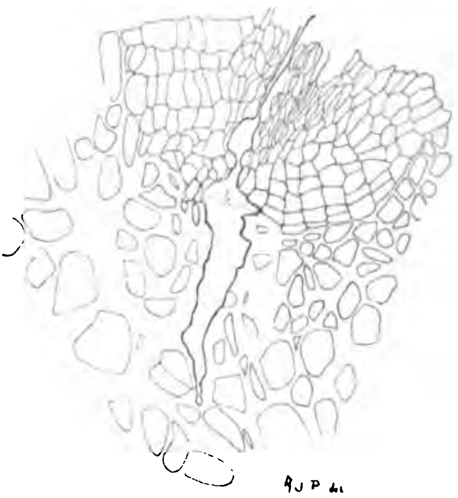
At present it can only be assumed that the spores germinate and penetrate the tissues soon after becoming ripe. The principal periods of infection would then be early spring, as soon as vegetation begins, or even earlier ; the other period would be from the middle of May to the middle of July, the time varying with the character of the season and with the locality. This subject is of the greatest importance when considered in its relation to the most favorable times for making applications designed to prevent the entrance of the fungus into healthy tissues.

From the fact that new knots show the first external indications of their presence only to a very limited extent in the fall, while the great majority of them do not form until spring, it would seem that infection takes place one year, but the knot does not develop until the following season. The manner in which the spores that mature in winter invest healthy tissues is not clear. There may be some relation between them and the formation of knots upon older wood, but the production of the spores in summer prevents the making of any definite statements which are not based upon careful artificial inoculations. As already stated, a great many knots are found in the forks of young branches, Fig. 3, 1, and at the places in which one year's growth stopped and that of the following year began, Fig. 3, 2. A careful examintion of the forks of the small limbs shows that the union of the two parts is not so close as at first appears. The cellular structure of these parts, as revealed by the microscope, is seen to be such that the spore of a fungus would apparently have less difficulty in gaining an entrance here than in almost any other place. Figure 1, A, represents a section made at the union of two twigs. The different parts of the limb are here shown so that their relative positions may be understood. The outer layer *ck* is composed of cork cells. These are penetrated with difficulty by the threads from a germinating spore, and it may be that entrance is entirely prevented by them. The layer lying under the one composed of cork cells is the cortex, *c o*. This layer as a rule contains no cells which are lignified, or woody, but is composed of cells which are easily penetrated by the mycelium of many fungi. Underneath the cortex is a layer known as the phloem. The phloem comprises the hard and the soft bast cells, only the former being woody. The soft bast cells can also be penetrated by the threads of the mycelium and offer no obstacle to the passage of such parasites. In this manner a fungus can penetrate without much difficulty to the cambium layer, *c a*, represented only by a dark line, when once the layer of cork cells has been passed; for the woody or lignified cells are arranged in isolated bundles so that they do not interfere with the inward growth of the threads of the mycelium, or vegetative portion of the fungus.



1.—*Crotch of branches where knots often form.*

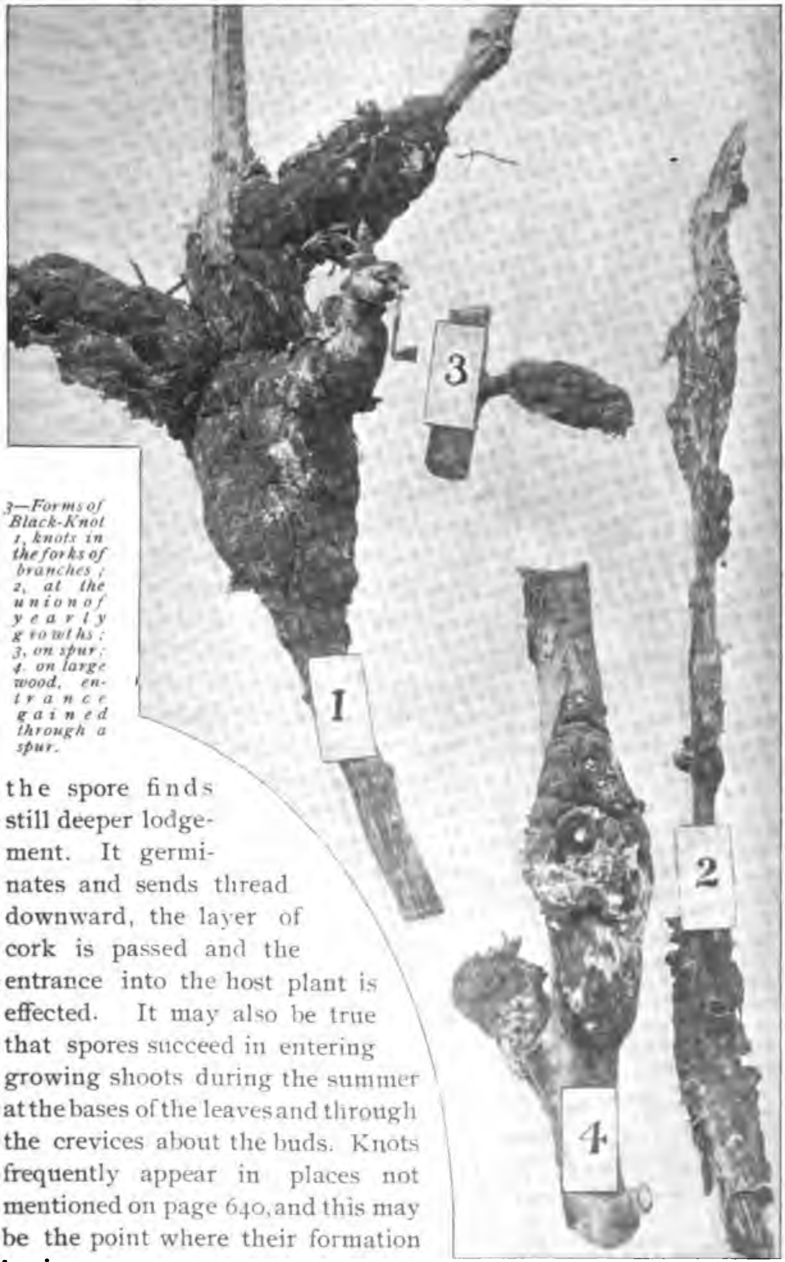
Diagram B of Fig. 1 represents only the layer of cork, more highly magnified, as found in the crotch of two small limbs. It will be noticed how deep is the crevice which extends downward from the point at which the two parts are apparently united. Another interesting feature of the diagram is the variable thickness of the layer. Where fully exposed to the air it is comparatively thick, but within the crevice it is much thinner, especially so in a few places. Diagram C shows the layer magnified still more, a section having been taken at the point *c* in B. The center cells are flattened to such an extent that they cannot be plainly seen.



2.—*Lodgement for spores in a crotch.*

Figure 2 represents a highly magnified termination of another crotch taken from a Morello cherry tree the wood being two and three years old. The point *b* in this diagram corresponds with *b* in diagram B of Fig. 1; it is the lower extremity of the cork layer. But this fork shows a fissure which prolongs the crevice naturally made. The layer of cork cells has been separated, and an opening made into the cortex lying underneath. The cells surrounding the fissure were tested for corky tissue and also for lignin, or woody fibre. These two substances were found not to be present. The threads of mycelium would therefore have little trouble in gaining an entrance. The fissure seen below *b* was not a new one, for the cell walls surrounding it were darkened as by exposure to air, and it is probable that they exist quite commonly in the forks of Morello cherry twigs.

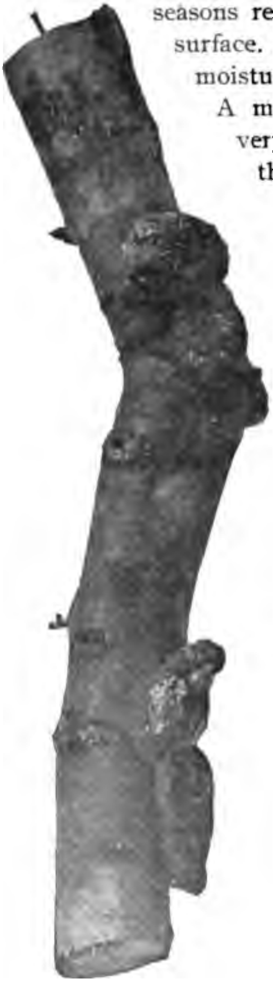
The manner in which the black-knot fungus gains an entrance into the forks of the smaller branches may thus be made fairly clear. A spore lodges in the crevice between the two branches; the action of the wind and the weight of the branches, especially when wet and bearing foliage, open the crevice more or less and



3—Forms of Black-Knot 1, knots in the forks of branches; 2, at the union of yearly growths; 3, on spur; 4, on large wood, entrance gained through a spur.

the spore finds still deeper lodgement. It germinates and sends thread downward, the layer of cork is passed and the entrance into the host plant is effected. It may also be true that spores succeed in entering growing shoots during the summer at the bases of the leaves and through the crevices about the buds. Knots frequently appear in places not mentioned on page 640, and this may be the point where their formation begins.

Number 2 in Fig. 3 shows two knots, each at the end of the growth of a season. The small lines running across the twig at the point of union of the parts formed in different seasons represent elevations and depressions in the surface. These would also afford protection and moisture to any spores which might lodge there. A microscopic examination shows also some very thin layers of bark, and it seems probable that an entrance could be affected here without much difficulty, provided atmospheric conditions are favorable.



4.—*Knot upon a large branch.*

Number 3 of the same illustration represents what may be considered as an explanation of the appearance of knots upon older branches (Fig. 4), or even upon the trunks of the trees. There can still be seen the remnants of small spurs which were probably first attacked. From these spurs the fungus entered the cambium layers of the larger portion, and thus the knot formed, and the part appears to have been directly attacked, although entrance in reality was gained through the spur, as is shown in No. 4 of the same figure.

These examples and many others of a similar character indicate that it is only comparatively young wood that is affected, the covering of the larger branches being so thick that it can withstand the attacks of the disease.

Remedies.—Although the black-knot fungus has been troublesome almost from the time that the stone fruits which it attacks have been grown in this country, no remedy has yet been found to be of value. The earlier literature upon the subject contains considerable advice regarding the treatment of the disease, but as its nature was not understood such remedies were founded mostly upon an unreliable basis. For example, it was recommended to dig about the base of the trees in the fall, and to keep chickens; the use of two or more quarts of salt per tree was considered of value; pulverized blacksmith's cinders scattered about the base of the trees prevented the disease; iron filings or scraps of old iron answered the same purpose; much importance was also attached to the nature and drainage of the soil in which the trees were growing. This list by no means includes all the suggestions made.

The preventive measure of cutting out the knots as fast as they appeared was strongly recommended from the earliest time, and this is still one of our best methods, if not the best, of checking the spread of this pest. The best time to do the work is in early spring when the new knots can be seen. This prevents the production of both crops of spores and will undoubtedly soon rid a neighborhood of the disease if the work is properly done. The next best time is in the fall, before the second crop of spores have matured. If the work is postponed until after these spores have been distributed the value of the operation will be almost entirely lost. From two to three inches of apparently sound wood should be cut away below the knot in order that no part of the fungus will remain in the portion left upon the tree. It has been generally advised to cover the cut surfaces with some material to prevent further infection at this point. Shellac, paint, and a solution of copper sulphate have been recommended for the purpose, but the value of the practice has not yet been determined and the labor of covering such surfaces may be very great. When the knots have been removed they should be buried or burned, so that no spores may mature after the operation, as sometimes occurs when the knots are left lying upon the ground. One individual cannot exterminate the fungus in a locality, and if no laws exist demanding the destruction of the knots, public sentiment should be brought to the point of making such demands. Laws framed for the purpose of controlling the black knot now exist in Michigan, New Jersey, New York, and Ohio.* California possesses laws aimed to keep all contagious plant diseases out of the state by means of the inspection of all imported stock; Ontario and British Columbia also possess laws designed for the better prevention of certain diseases of plants. If existing laws were enforced the extent of injury from the black knot fungus would be very greatly diminished. Unfortunately the above measures have not in all cases been as effectual as was hoped, and individual efforts are still required to free a locality from the pest.

The black-knot fungus may be destroyed while upon the tree, but the operation is tedious. The knots are painted with some liquid which will penetrate their interior, or form a coating over them which excludes the air. As early as 1855 spirits of turpentine† was used for this purpose. Kerosene was used in the same manner ten or fifteen years later, and linseed oil has been tried with apparent success. Kerosene and turpentine must be used with caution, for if a heavy application is made the branch beyond the diseased point will be destroyed and I have seen young plum trees killed outright by a too free use of kerosene. Linseed oil can be used with safety. It is advisable to use some coloring matter, as the red oxide of iron or white lead, to show what parts have been well covered. But the best way of disposing of the knots is to cut them out and burn them.

Since the discovery of the fungicidal properties of some of the copper compounds the remedies which are effective in controlling other fungous diseases have, to a limited extent, been recommended for the prevention of black knot. Very few, however, seem to have tried the experiment. The only recorded case which I have found is that of Maynard.‡ Certain plum trees were sprayed April 19 with a solution made by dissolving one pound of copper sulphate in twenty-two gallons of water. May 19 the application was repeated, but Paris green was added at the rate of one pound to five hundred gallons of the solution. This injured the foliage severely, so the Bordeaux mixture was used for later treatments which were made May 21 and 29, June 7 and 17, July

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* A copy of the New York law may be found on page 392, Bulletin 75 of this station.

† *The Country Gentleman*, 1855, p. 106.

‡ Mass. Hatch Agric. Exp. Sta. Bull. 11, Jan. 1891, p. 19.

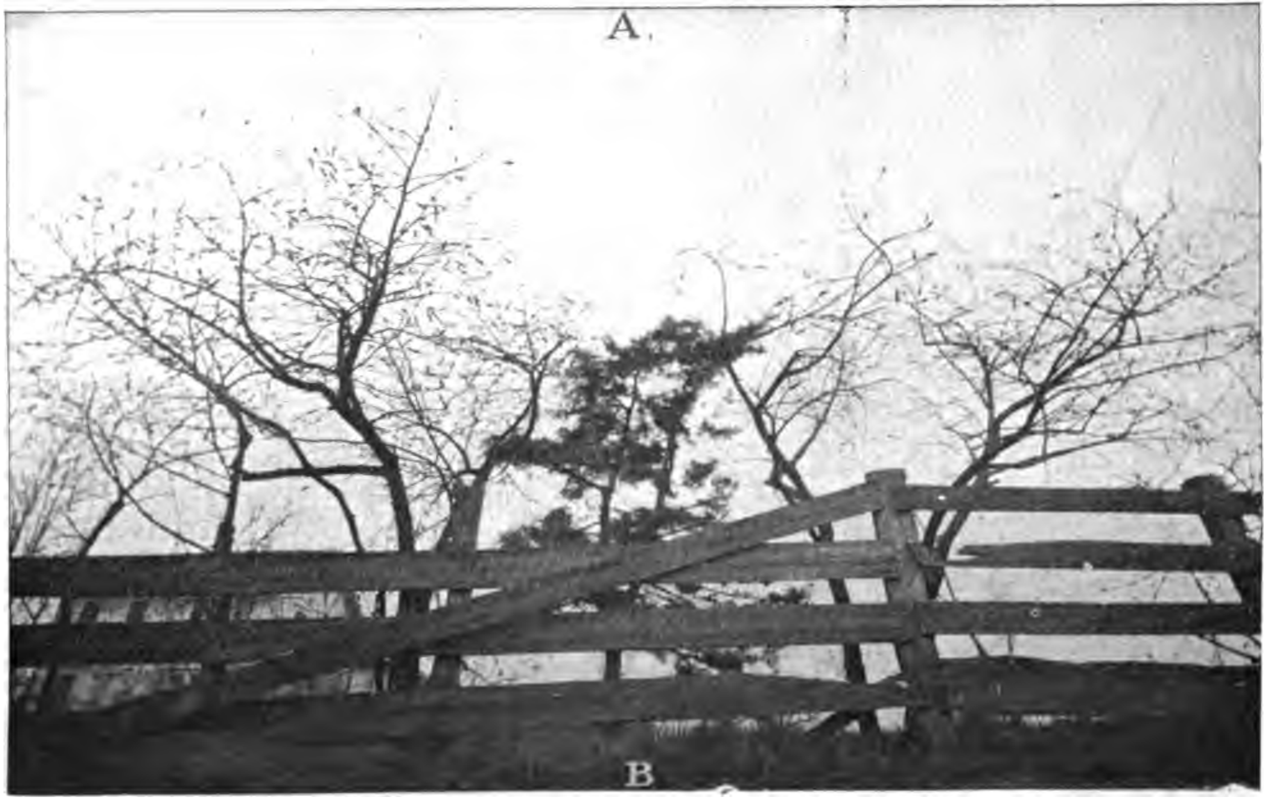
19 and 29. The conclusion reached was that "the number of warts was *very decidedly* less where treated with the copper mixture, than where untreated * * * and we believe that the plum wart may be held in check by this remedy."

In the spring of 1893 some experiments were begun with the intention of carrying on the work at least two seasons. A thicket of Morello cherry trees and sprouts was chosen for one field of operations. The plants were well covered with knots at the time, and these were all allowed to remain until the following year. The piece was divided into two nearly equal parts by cutting out the brush across a convenient portion of the strip. One part was treated and the other was not. The only fungicide used was the Bordeaux mixture. This was applied in 1893 upon the following days: March 29, April 18, May 6 and 30, and June 13. The trees were as well covered as could be done, but some of the parts were difficult of access.

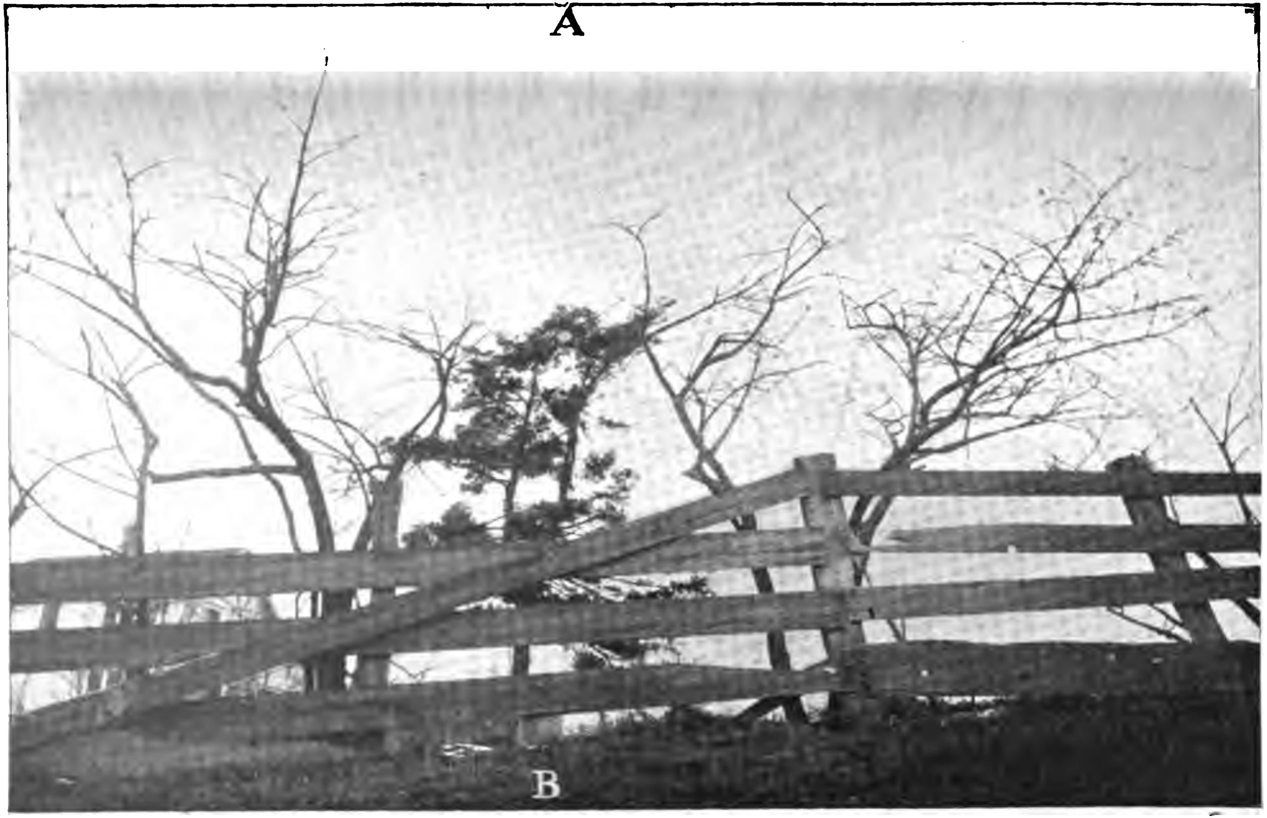
The work was continued in 1894, and after one application had been made all the knots were cut out. This was done April 25, and the knots from each portion were counted so that the relative number of branches in each portion could be estimated and a basis for comparison might be made when the knots should again be cut. They had been allowed to remain on the tree during the preceding year so that the chances for further infection should be as favorable as possible. At the time of their removal no marked difference could be seen in favor of either portion as regards the relative abundance of the knots, although on the sprayed portion they may not have been quite so thick.

The Bordeaux mixture was again used in 1894. It was applied to the same portion treated in 1893 and upon the following dates: April 9 and 25, May 21, June 6 and 27, July 10 and 20, and August 1. This number of treatments gave the limbs and foliage a blue color which they retained until the leaves fell to the ground, and at this writing, December 3, the branches still show a decided coloration.

Figure 5 represents the thicket as it appeared November 26 before the knots were cut out after the summer's growth. The illustration does not represent plainly the number of knots present, but it will be noticed that there are many more on the unsprayed



5.—*Spraying for Black-Knot. Photograph taken in November, before the knots were cut The line A B marks the division of the plants. Left hand part untreated, the other sprayed with Bordeaux Mixture.*



6.—*Spraying for Black-Knot. The same as Fig. 5, after the knots were cut. Observe the severe pruning of the untreated part (to the left) as a consequence of the removal of the knots.*

than upon the sprayed part. The line between the two plots passes across the page from *A* to *B*. The knots were all cut out after the photograph was taken. The appearance of the thicket after the operation is shown in Figure 6. It will be noticed what a large proportion of small branches has been removed from the unsprayed part. When the value of these branches is considered, the seriousness of this loss can be realized. The sprayed portion lost but a very small number of such twigs and is still in very good condition. The table below shows the numbers obtained in the spring and those removed in the fall. By the term "new" knots are meant those which appeared to have been produced by a new infection; "old" knots are those which apparently grew from the mycelium which had not been removed when the knots were cut in the spring.

April 25, 1894.

Unsprayed portions, knots removed - - -	2002
Sprayed " " " - -	1155

November 26, 1894.

Unsprayed portion, total number removed	3529	—new knots	3466
Sprayed " " " "	240	" "	165

The above figures are full of encouragement. They show, not that the black knot fungus has been held under absolute control, (and what fungous disease is,) but that it is susceptible to treatment. There was a large increase, nearly 57 per cent., in the number of knots cut in the fall from the unsprayed portion over those cut in the spring. Had the same proportionate increase taken place in the sprayed part, a supposition which must be allowed had no applications been made, the number of knots produced would have been within a fraction of 2000. Consequently, the 165 new knots should be compared with 2000, and not with 1155 as shown by the table. It must also be considered that this reduction took place in the face of circumstances which had been made as favorable for the spreading of disease as possible. The sprayed portion had been covered with knots during the first year's treatments. It was practically in contact with a large number of diseased plants. And finally, we are still in the dark as to the best time of making the application, for we do not know with certainty when the infections take place, nor when the knot appears after infection has occurred. If this were known the matter would be considerably simplified, and still better results obtained. It would appear from the above that an orchard may be kept practically free from the knot if the trees are sprayed at the proper time. One or two treatments might be given before the blossoms open, and later applications probably need not be made oftener than is required to control the leaf-blight and the rotting of plums. If in addition to this the comparatively few knots which will undoubtedly appear be removed as soon as discovered, no grower need have much fear of this disease even though his trees be considerably exposed to infection from neighboring trees or thickets. The treatments which the above* experiment seems to justify me in recommending are as follows:

First. During the latter part of March or early in April.

Second. When the buds are beginning to swell.

Third. During the latter part of May, or as soon as the new knots begin to show their velvety coating.

Fourth. About two weeks after the third.

Fifth and Sixth. At intervals of two or three weeks after the fourth, but these two will probably not always be necessary.

The Bordeaux mixture may prove more valuable than other fungicides even in making the first applications, as it adheres better to the branches. It is probable that some of the above treatments may in time be dispensed with. Much will depend upon the season and upon the degree of infection to which the orchards are exposed.

It is scarcely necessary to add that all thickets, hedges, and useless trees which serve as breeding and distributing centers should be destroyed at the first opportunity. The species of Prunus mentioned on page 641 should be served in the same manner as useless cultivated plants, if they aid in the propagation of the fungus. In the end unceasing vigilance must bring its reward.

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*It is unfortunate that other experiments begun at the same time and carried on in a manner similiar to the above have failed to give results from the fact that no new knots formed upon either the sprayed or the unsprayed portions. The plum orchard of Geo. T. Powell, Ghent, N. Y., has been under treatment during two years, as well as other trees in the vicinity of Ithaca. All have failed to develop new knots. But the work will be coninued and it is hoped to make other reports in the future.

SUMMARY.

1. The black-knot of plums and cherries was first troublesome in the Atlantic states. Page 637.

2. Its presence west of the Alleghany mountains seems to be due at least in part to plants introduced from the eastern states. Page 637.

3. The first swelling of the knot occasionally begins in the fall but is generally first noticeable in the spring. Page 638.

4. The young, growing knot is yellowish brown in color, but this color changes to black as the season advances. Page 638.

5. Knots most commonly form in the forks of young branches, at the union of the growths of two seasons, and upon the small spurs which commonly bear the fruit. Page 640.

6. The cause of the black-knot is a fungus, *Plowrightia morbosa*. Page 641.

7. The fungus produces from each knot one crop of spores during the early part of the season, and another during midwinter, after which the central portion of the knot dies. Page 641.

8. Black-knots are very generally infested by insects, but these are not the cause of such swellings. Page 641.

9. The time in which the spores produced by the fungus gain an entrance into the branches is not definitely known, but it seems probable that this occurs soon after the ripening of the spores. Page 642.

10. The manner in which the spores penetrate the outer tissues has not yet been observed; but the fact that the layer of cork is thinnest, or entirely wanting, in those places in which the greater number of knots are found leads to the conclusion that the fungus can penetrate the outer tissues at these points, but cannot enter at all places. Pages 643, 644.

11. Knots found upon old wood first obtained a foothold upon younger wood, from which they spread to the older parts. Page 646.

12. Many remedies for the black knot have been suggested but none have proved to be efficient. Page 647.

13. The most generally recommended preventive measure is to cut out the knots and destroy them. This work should be

done as soon as the knot is observed, and if well carried out it is an excellent method of exterminating the disease. Page 647.

14. Since fungicides have come into use, spraying for the black-knot has been recommended. Page 648.

15. The conclusions drawn by Maynard from the experiments of one season recorded by him were that "the number of warts was *very decidedly* less where treated with the copper mixture, than where untreated. * * * and we believe that the plum wart may be held in check by this remedy." Page 649.

16. A thicket of Morello cherries which had been treated during two seasons by this station produced only 165 new knots. Page 652.

17. From another portion of the same thicket which had not been treated there were cut 2002 knots on April 25, 1894. On November 26 of the same year this portion yielded 3466 new knots, an increase of nearly 58 per cent. Page 652.

18. Had the sprayed portion remained untreated it may be supposed that a similar increase would have taken place in this part, making the assumed number cut within a fraction of 2000. Page 652.

19. The reduction of the number of knots from 2000 to 165, considering the present state of our knowledge, and the conditions under which the experiment was carried on, are encouraging, and point to a final control of the disease. Page 652.

20. Some of the applications which now appear necessary for the control of the black knot are to be made when other diseases require treatment. This necessitates but little extra labor in spraying for the prevention of the knots. Page 653.

21. The spraying of plums and cherries to protect them from the black-knot fungus, as stated on page 653, can be carried on with profit in all sections where this disease threatens to interfere seriously with the profitable cultivation of these fruits.

E. G. LODEMAN.

FORMULAS.

BORDEAUX MIXTURE.

Copper sulphate	6 pounds
Quicklime	4 "
Water	40 gallons

Dissolve the copper sulphate by putting it in a bag of coarse cloth and hanging this in a vessel holding at least 4 gallons, so that it is just covered by the water. Use an earthen or *wooden vessel.* Slake the lime in an equal amount of water. Then mix the two and add enough water to make 40 gallons. It is then ready for immediate use. For rots, moulds, mildews, and all fungous diseases.

AMMONIACAL COPPER CARBONATE.

Copper carbonate	1 ounce
Ammonia	enough to dissolve the copper
Water	9 gallons

The copper carbonate is best dissolved in large bottles, where it will keep indefinitely, and it should be diluted with water as required. For same purpose as Bordeaux.

COPPER SULPHATE SOLUTION.

Copper Sulphate	1 pound
Water	15 gallons

Dissolve the copper sulphate in the water, when it is ready for use. *This should never be applied to foliage, but must be used before the buds break.* For peaches and nectarines use 24 gallons of water. For fungous diseases.

PARIS GREEN.

Paris green	1 pound
Water	250 gallons

If this mixture is to be used upon peach trees, 1 pound quicklime should be added. Repeated applications will injure most foliage, unless lime is added. *Paris green and bordeaux can be applied together with perfect safety.* The action of neither is weakened, and the Paris green loses all caustic properties. For insects which chew.

LONDON PURPLE.

This is used in the same proportion as Paris green, but as it is more caustic it should be applied with the lime, or with the Bordeaux mixture. Do not use it on peach or plum trees. For insects which chew.

HELLEBORE.

Fresh white hellebore	1 ounce
Water.	3 gallons

Apply when thoroughly mixed. For insects which chew.

KEROSENE EMULSION.

Hard soap	½ pound
Boiling water	1 gallon
Kerosene	2 gallons

Dissolve the soap in the water, add the kerosene, and churn with a pump for 5–10 minutes. Dilute 10 to 15 times before applying. For insects which suck, cabbage worms, and all insects which have soft bodies.

Bulletin 82. **December, 1894.**

Cornell University Agricultural Experiment Station,

VETERINARY DIVISION.

EXPERIMENTS

WITH

Tuberculin on Nontuberculous

COWS.

By JAMES LAW.

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BULLETINS OF 1894.

62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf-Blight of the Strawberry.
80. The Quince in Western New York.
81. Black-Knot of Plums and Cherries, and Methods of Treatment.
82. Experiments with Tuberculin on Nontuberculous Cows.

EXPERIMENTS WITH TUBERCULIN ON NON-TUBERCULOUS COWS.

On October 28th, 1894, the following cows were set apart for this experiment: two Holstein cows and one Jersey in full flow of milk, being about six weeks after calving, and two dry, farrow cows of common stock, one pointing to a Short-Horn ancestry and the other to a Devon one. Meanwhile observations on the milk of three other cows, two Holsteins and a Jersey, about the same length of time after calving, afforded a fair comparison between cows treated with tuberculin and others under similar conditions but without such treatment.

The first five cows to be tested with tuberculin, each received in proportion to its size, a full dose of tuberculin weekly and the temperatures were taken before the injection for the normal standard and about every two hours from about the ninth to about the twentieth hour after each tuberculin injection.

TEMPERATURE.

The tested animals were treated like the rest of the herd with the single exception, that in order to take the temperatures, they were tied up in the stalls for twenty-four hours on each occasion for testing, while the others were at liberty under an enclosed shed except when tied up for feeding and milking. The prolonged standing on hard boards, led on each occasion to congestion of the feet of the Holstein cow Mabel, which weighed 1455 lbs., but as this invariably took place under similar circumstances and apart from the injection of tuberculin, the slight rise of temperature on each occasion of testing is abundantly accounted for from the condition of the feet alone. This conclusion is further confirmed by the fact that, excepting in cases in which she was turned out in the afternoon to relieve her tender feet, the temperature went on steadily increasing to the last. This was notoriously the case in the three last tests of the series (Nov. 28th, Dec. 7th, Dec. 12th). On a previous occasion Mabel had been tested in company with the entire herd and stood the test satisfactorily. Even in the present series of tests, this cow (with one exception) never rose more than two degrees above her initial temperature taken when that particular test was started, and she only rose nine-tenths of a degree above 102F.°, which may be set down as the normal standard temperature of a cow in full milk, highly fed and kept indoors. Taking into account the variations in healthy cattle from one time of the day to another, this rise of less than one degree above the general standard implies nothing.

The exceptional case was on Nov. 9th and 10th, when Mabel's temperature rose to 104° and that of the Short-Horn grade to 104.3°. Taken by itself this test might have been misleading, but in connection with six other tests (in case of Mabel seven) made both before and after this, with the same dose of tuberculin and with no such resulting rise, it can safely be set down to accidental conditions. The real cause was not clearly made out, but it is probable that it was chargeable on exposure in a cold draught. Both cows stood on separate ranges close to the east door of the barn, through which the manure had to be forked out, and with a cold east wind entering by that door, and blowing on cattle that had been shut up in a warm building over night, a slight chill was to be expected.

The Jersey, *Daisy*, never rose above the normal standard of 102°, excepting in the first test and then only to 102.3°—too little to furnish even a suggestion of tuberculosis, no higher than we find in many well fed healthy cattle.

The Holstein, *Belva*, on two occasions rose to 102.5°, half a degree above the normal standard, but which is often attained to in health, and apart from the tuberculin test. Moreover on five other tests both before and after these she did not show a rise over 102° so that the less suspicion should arise from this insignificant elevation.

The Devon grade cow in different tests had her temperature elevated to 102° and on one occasion to 102.6°, a little more than half a degree above the normal, and which, as already said is found in the healthiest cows.

The Short-Horn grade had a fever temperature on one occasion apparently from a chill as already referred to. In her first test it rose to 102.6° as did also the Devon grade on the same occasion. This may be explained partly by the fact that both had been driven a distance of seven miles the day previous causing much excitement, and followed by the excitement induced by coming into a new place and herd, and among new people.

One other point should be named as affecting the temperatures of all the test animals in the early forenoon and late afternoon. The whole herd was put in the barn for feeding and milking, from five to seven in the morning and from three to six in the afternoon, so that at these hours the place was crowded and the disturbance greater. Elevations of temperatute of a degree and under occurring at such time, and as repeatedly seen in the tested animals are thus accounted for. Such elevations do not show the persistence and the slow gradations of rise and fall which we usually see in the rise caused by the tuberculin.

Taken all in all then there is nothing in the records of temperature that would indicate, either at the time of the test, or later, that the tuberculin had proved in any way inimical to the general health. Had the health been impaired by the repeated operation of the tuberculin it might have been expected that the constitutional disturbance would have been more distinctly marked in the later tests than in the earlier ones, and as no such tendency is observable it may be safely concluded that so far as illness can be indicated by a variation of temperature, test doses of tuberculin, in the absence of the bacillus, does not seem to produce any such illness in the healthy animal.

It has been alleged that the repeated use of tuberculin on animals slightly tuberculous, abolishes the tendency to reaction under the use of this agent. If this were true it would argue rather a curative than a malific action of the tuberculin, but in other experiments, I have found the second test made a week or more after the first to produce a no less marked reaction, so that this alleged tolerance need not be taken into account in the cases before us.

RESPIRATION AND PULSE.

As regards the record of the pulse and breathing given in the tables it is sufficient to say that they furnish no real indication of a deviation from the most perfect health. In cattle pulse and breathing vary so widely under different conditions of the environment, digestive organs, exercise, etc., that it would take very much greater variations than those given in the tables to give true indications of disease.

MILK RECORD.

The milk record may be accepted as a more sensitive test of constitutional injury than temperature, breathing or pulse. It is also farther reaching than these other indications, as it involves a healthy exercise of all the bodily functions, and above all those of appetite, digestion, assimilation and secretion. An appreciable disturbance of the health at any one point will usually be manifested in this delicate balance in a variation of quantity or quality of the milk.

Belva. Taking the milk record of Belva as given in table VI, we find that the milk yield in the twenty hours following the injection of the tuberculin shows no constant nor striking difference from that of intervening days. The highest yield per day (42.25 lbs.) was on the fifth day succeeding the third injection of tuberculin, and on each of these five days the yield was from two to five pounds above the average. The lowest yield per day (31.5 lbs.) was on the fourth day after the first injection, while the preceding day's yield had been over a pound above the average, and the two days following the injection had been respectively two and three pounds below.

What is more significant is that the average yield of milk for the days following the seven injections of tuberculin is practically the same as the average yield for the whole 47 days included in the experiment. This may be stated clearly in tabular form thus:

Average of the seven days following the injections of tuberculin 37.257 lbs.

Average of the forty-seven days for which the milk record is given 37.247. The difference is 0.01., and is in favor of the days when the system was charged with the dose of tuberculin.

Daisy. The milk record of Daisy given in Table VII shows a great difference in the yield on different days, but no constant relation between the low daily yield and the days when the tuberculin was in the system. On the first, second, and fourth occasions in which the system was charged with the tuberculin the milk-yield was above the average, whereas on the third, fifth, sixth and seventh occasions it was below. The highest daily yield (22.25 lbs.) was on the day in the evening of which the first injection of tuberculin was made, and the second highest (21.5 lbs.), only three-fourths of a pound less, was on the day after that injection. The lowest daily yield (15 lbs.) was on the day when the last injection of tuberculin was in the system, and when besides the cow was in *heat*. This low yield was also reached on the day preceding the second last tuberculin injection (the ninth day after an injection), and also on the succeeding day when the system was charged with this second last injection. This low record could not be justly charged on the tuberculin injection seeing that it was already reached the day before that injection.

Daisy, like the rest of the herd, was falling off in milk during the experiment, and her average when charged with tuberculin suffers on account of her having reached her lowest mark on Dec. 7th on the evening on which a dose of tuberculin was given, and further, that on Dec. 13th the day of the last test, her milk shrank because she was in heat. Taking the seven tests the averages stand thus:

Average of the seven days following the injections of tuberculin 17.82 lbs.

Average of the forty-seven days for which the milk record is given, 18.26 lbs. This shows a difference of less than half a pound daily on the average against the tuberculin. If we leave out the last injection (Dec. 13th) when the cow was in heat, we find that the average yield per diem for the six days during which the cow was charged with tuberculin is slightly above the average for the whole forty-seven days of the trial.

Molly, Freda and Bertha. These cows were not injected with tuberculin and their milk records have been introduced to show that the daily oscillations in the yield and its progressve diminution in the main during the forty-seven days, was common to the whole herd and in no sense peculiar to the three cows that had been treated with tuberculin. The gradual failure can be seen in the tables. It may be more clearly shown by placing side by side the general average for the first four weeks and the average for the last two weeks and five days.

Average for 1st twenty-eight days:

Belva lbs.	Molly lbs.	Freda lbs.	Daisy lbs.	Bertha lbs.
38.10	41.31	43.51	19.23	28.46

Average for last nineteen days:

Belva lbs.	Molly lbs.	Freda lbs.	Daisy lbs.	Bertha lbs.
36.00	42.87	40.51	16.76	26.13
—2.10	+1.56	—3.00	—2.47	—2.33

Molly has gone on improving but the others show a very decided falling off which is greater in the noninjected Freda than in the injected Daisy, and greater in the uninjected Bertha than in the injected Belva.

Oscillations. The variations above and below the general average for each animal injected and not injected with tuberculin will be very clearly seen by glancing at the tables giving the graphic illustration for two Holsteins and two Jerseys (Tables VIII and IX). In figures they may be shown as follows:

Belva. General average per day 37.247 lbs. Highest per day 42.25 lbs. Lowest per day 31.50 lbs.

Freda. General average per day 41.78 lbs. Highest per day 47.50 lbs. Lowest per day 34.50 lbs.

Daisy. General average per day 18.26 lbs. Highest per day 22.25 lbs. Lowest per day 15 lbs.

Bertha. General average per day 27.01 lbs. Highest per day 33.5 lbs. Lowest per day 23 lbs.

Molly. General average per day 41.19 lbs. Highest per day 48 lbs. Lowest per day 33.5 lbs.

The extremes it will be observed were actually greater for the cows that were not treated with tuberculin than for those so treated. Among the Holsteins *Belva* had a variation amounting to 10.75 lbs., *Freda* one of 13 lbs., and *Molly* one of 14.5 lbs. Among the Jerseys, *Daisy* had a variation of 7.25 lbs. and *Bertha* one of 10.5 lbs. Extreme variations in the yield of milk then cannot be charged on the action of a test dose of tuberculin injected into a healthy animal, nor of a series of such test doses administered at intervals of a week.

PERCENTAGE OF BUTTER-FATS IN THE MILK.

Before dismissing the milk it is desirable to consider how the ratio of butter-fats is affected by repeated test doses of tuberculin injected into a healthy animal. A study of the tables given below will fail to establish any connection between the presence of a test dose of the tuberculin in the animal body, and any increase or diminution of the fat in the milk. The Holstein *Belva* had her highest percentage of butter-fat (3.6) October 20th, ten days before the first injection of tuberculin. Her next highest record (3.4) was Dec. 8th while under the action of tuberculin. Her lowest record (2.8) was Dec. 1st, two days after the operation of a dose of tuberculin. Her variation (0.8) is only a little more than that of the untreated cow Freda (0.6), and only about half that of Molly (1.5). The Jersey *Daisy* also made her highest percentage (5.6) October 20th and her lowest (4.8) December 8th when under the action of tuberculin. But she made her second highest (5.55) Nov. 10th when under tuberculin and an equal record Nov. 17th two days after the operation of a dose of tuberculin. Her greatest variation was 0.7 per cent., whereas, that of the untreated cow Bertha, was 1.15 per cent.

There is therefore no change in the percentage of butter-fats sufficient to indicate any disease or ill-health as the result of the administration of repeated test doses of tuberculin.

EFFECT ON BODY WEIGHT.

The weight of the animals varied so little during the experiment that it might be said to have remained stationary. The record is as follows:

	October 30th.	Dec. 1st.	Dec. 13th.	Jan. 5th, 1895.
Belva,	1264 lbs.,	1305 lbs.,		1405 lbs.
Mabel,	1455 "	1540 "		1570 "
Daisy,	945 "	950 "		965 "
Short Grade Horn,		1020 "	1020 lbs.,	1025 "
Grade Devon,		895 "	915 "	910 "

Considering that a variation of 50 lbs. in the weight of a cow may occur in a few hours according as it is taken before or after feeding and watering or milking, there may be said to have been no change excepting in the case of the two Holsteins in which there is shown a gain of 141 lbs. and 115 respectively. It is worthy of notice that the last weighing, which makes the highest record was made three to four hours after the morning feeding, and (in the case of the three first cows) of the morning milking. The two dry cows had been watered but had not been fed on the morning of the last weighing as they were just about to be killed.

It may be concluded that the repeated test doses of tuberculin had in no injurious way affected assimilation and that, in the two Holstein cows, it had not prevented a perceptible improvement in this respect.

POST MORTEM EXAMINATIONS.

To complete the record the two farrow cows were killed Dec. 5th, 1894, and subjected to careful necropsy. In the main the viscera were sound. The shorthorn grade had pus in each of the left quarters of the mammary gland in the milk sinus, the walls of which were red and thickened. When stained and placed under the microscope, the pus showed numerous cocci but no bacilli.

As is usual in old cows, the groups of lymphatic glands in the intermaxillary and pharyngeal regions, in the chest, the abdomen, the subcutaneous and intermuscular regions were pigmented of a dark grayish color, varying at different points but in no case showing molecular degeneration, coagulation-necrosis (casseation) nor even perceptible congestion. In the shorthorn grade the lymphatic glands behind the diseased mammae were considerably enlarged.

EXPERIMENTS AT THE U. S. BUREAU OF ANIMAL INDUSTRY.

In the "investigations concerning bovine tuberculosis 1894," Dr. Schweinitz records the effect on the milk of two healthy cows one of which received one dose and the other three successive doses of tuberculin. The dose on each occasion was 2 cc. for each cow and as they were common stock it may be inferred that it was a full dose considering the probable weight of the animals. Of variations in temperature it is enough to say that there was no more than would occur in the best of health. The analysis of the milk is given in table XII from which it will be seen that the single test of cow No. 113 there was a slight reduction of the total solids, and of the different constituents such as sugar, albuminoids and fat. The second cow, No. 217, tested three times under tuberculin and once on five successive days without tuberculin gives a more trustworthy basis for estimating the effect of that agent. It will be observed that on April 1st under the tuberculin there was a slight decrease of the total solids (0.45), on April 13th under tuberculin a still larger decrease (1.26), but on June 5th under tuberculin there was an increase (1.01). On June 11th to 15th without tuberculin there was a variation in the total solids of 1.99.

Then as to the milk sugar, 217 showed a percentage reduction of 0.1 April 1st under tuberculin and of .61 April 13th, but no change whatever June 5th though again under tuberculin and no change June 11th to 15th without tuberculin.

Of albuminoids 217 showed a percentage reduction of .07 April 1st under tuberculin, but an increase of .13 April 13th and .61 June 5th. In the absence of tuberculin it showed a variation of .42 June 11th to 15th.

In fat, No. 113 had a decrease in her single test, while 217 had an increase in all cases under tuberculin .31 April 1st, .13 April 13th, and .86 June 5th. In the entire absence of tuberculin June 11th to 15th she showed a variation of .51.

With such a testimony it would be disingenuous to claim, any constant or appreciable variation as the result of the injection of a test dose of tuberculin, into a healthy animal even if such dose were repeated several times. So far as there is evidence before us, everything points to the harmlessness of a single test dose on a sound animal system.

JAMES LAW.

Cornell University, Ithaca, N. Y.,
January 8th, 1895.

TABLE I.

ACTION OF TUBERCULIN ON HOLSTEIN COW BELVA IN FULL MILK.

Before Injection.						After Injection.							
Date 1894.	Norm. Temp.	Resp.	Pulse.	Tuberculin Dose.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Oct.	Deg.				P. M.	Deg.			A. M	Deg.			A. M
30-31	101	. .	. .	30m	9:45	102.1	. .	. .	6:45	101.5	30	72	9:15
Nov.					P. M.				A. M.				A. M.
9-10	101.3	. .	. .	30m	10:00	101.8	16	. .	7:00	100 2	13	. .	9:30
					P. M.				A. M.				A. M.
14-15	101	15	. .	30m	10:30	101 6	18	. .	7:30	100 8	16	. .	9:30
					A. M.				P. M.				P. M
23	101	24	. .	30m	7:00	101.5	16	. .	2:30	101.6	21	. .	4:00
					P M				A. M.				A. M.
28-29	100	13	. .	30m	10:15	101.8	18	. .	7:00	100.5	14	. .	9:15
Dec.													A. M.
7-8	101.5	20	. .	30m	10:30	101.9	21	72	7:30	100.4	12	72	10:00
12-13	100.8	20	63	30m	10:30	101.5	16	. .	7:15	101.4	16	. .	10:15

TABLE II.

ACTION OF TUBERCULIN ON HOLSTEIN COW MABEL IN FULL MILK.

Before injection.						After injection.							
Date 1894	Norm. Temp.	Resp.	Pulse.	Tuberculin Dose.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Oct.	Deg.				P. M.	Deg.			A. M	Deg.			A. M.
30-31	100.9	. .	. .	31m	9:45	100 9	. .	. .	9:45	102.6	28	. .	9:15
Nov.					P. M.				A. M.				
9-10	101 4	. .	. .	31m	10:00	102.8	18	. .	7:00	104	22	. .	9:30
					P. M.								A. M.
14-15	101	23	. .	31m	10:30	101.5	18	. .	6:46	101.9	16	. .	8:30
					A. M.				P. M.				P. M.
23	101.9	22	. .	31m	7:00	102	18	. .	2:30	102.5	21	. .	4:00
					P. M.				A. M.				A. M.
28-29	101.5	14	. .	31m	10:15	102	21	. .	7:00	100.9	16	. .	9:15
Dec.									A. M.				A. M.
7- 8	101.4	18	. .	31m	10:30	102	20	. .	7:30	101.6	24	. .	10:00
									A. M.				A. M.
12-13	102	24	63	31m	10:30	102.6	18	. .	7:15	102.6	24	. .	10:15

TABLE III.

ACTION OF TUBERCULIN ON JERSEY COW DAISY; CALVED SEPT. 12, 1894.

Before injection.						After injection.							
Date 1894.	Norm. Temp.	Resp.	Pulse.	Tuberculin Dose.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Res .	Pulse.	Hour.
Oct.	Deg.				P. M.	Deg.			A. M.	Deg.			A. M.
30-31	101	. .	. .	26m	9:45	101.8	. .	. .	6:45	101.5	30	72	9:15
Nov.					P. M.				A. M.				
9-10	101	. .	. .	26m	10:00	101.6	24	72	7:00	100.8	12	. .	9:30
					P. M.								A. M.
14-15	100.8	21	. .	26m	10:30	101.8	23	. .	6:45	100.9	9	. .	9:30
					P. M.				A. M.				A. M.
22-23	101	18	72	26m	10:20	101.5	21	. .	7:00	101	15	66	9:30
					P. M				A. M.				A. M.
28-29	101	15	. .	26m	10:15	101.7	15	. .	7:00	100.5	16	. .	9:15
Dec.									A. M.				A. M.
7- 8	101.5	27	. .	26m	10:30	101.8	30	54	7:30	100.9	18	62	10:00
									A. M.				
12-13	101.3	29	66	26m	10:30	101.7	16	. .	7:15	100.3	18	60	10.15

TABLE I.

CALVED SEPTEMBER 16TH, 1894.

AFTER INJECTION—

Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Hour.
Deg.			A. M.	Deg.			P. M.	Deg.			P. M.	Deg.		P. M.
101.5	30	60	11:25	102.3	15	.	1:45	101.9	20	69	4:15	102		6:45
101.5	. . . .		11:30	101.7	17	. .	P. M. 2:00	101.4	18	. .	P. M. 4:00	101	20	6:30
101.2	16	. .	11:30	101.5	15	. .	P. M. 1 00	101.8	13	. .	P. M. 3:00	102.5	20	P. M. 5:00
101.5	17	. .	P. M. 7:00	101	15	. .	P M. 10:00							
101	16	. .	A. M. 11:45	101 9	20	60	P. M. 2:00	102.5	14	. .	P. M. 4:00			
100.9	20	60	P. M 12:10	101.8	16	66	P. M. 3:00	101 6	20	. .	P. M. 4:45			
101.3	16	60	P. M. 12.15	101.6	18	. .	P M. 2:15	101.7	. . . .		P. M. 4:30	Was in heat Dec. 11th		

TABLE II.

CALVED OCTOBER, 1894.

AFTER INJECTION—

Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Hour.
Deg.			A. M.	Deg.			P. M.	Deg.			P. M.	Deg.		P. M
102.9	42	72	11:25	102.6	32	. .	1:45	102.2	26	72	4:15	101.5	. .	6:45
102.8	26	. .	11:45	102.6	18	. .	P. M. 2:00	101.7	22	. .	P. M. 4:00	101.5	19	6:30
101.8	18	. .	11:15	102	18	. .	P. M. 1:00	102.2	21	. .	P. M. 3:00	102	20	P. M. 5:00
102.2	24	. .	P. M 7:00	102	22	. .	P. M. 10:00							
101.9	14	. .	A. M. 11:45	101.7	14	. .	P. M. 2:00	102.2	18	. .	P. M 4:00	102.5	24	P. M. 5:20
102.3	20	. .	P. M. 12:10	102.8	16	. .	P. M. 3:00	102.6	12	. .	P. M. 4:45	Feet sore from standing on boards.		
102.9	16	60	12:15	103.2	31	. .	P. M. 2:15	103			P. M. 4:30			

TABLE III.

AFTER INJECTION—

Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Hour.
Deg.			A. M	Deg.			P. M.	Deg.			P. M.	Deg.		P. M.
101.5	30	60	11:25	102.3	15	. .	1:45	101.9	20	69	4:15	102	. .	6:45
101.2	17	.	11:45	101.7	20	.	P. M. 2:00	101.8	22	. .	P. M. 4:00	101.2	18	6.30
101	16	. .	11:15	101	17	. .	P. M. 1:00	101.2	22	. .	P. M. 3:00	101.7	20	P. M. 5:00
100.8	15	. .	A . M 11:30	101 3	15	. .	P. M. 2:30	101.5	17	. .	P M. 4:00	101.3	24	P. M. 7:00
												101.4	. .	10:10
100.5	18	. .	A. M. 11:45	101.2	14	48	P. M. 2:00	101	14	. .	3:00	101.5	. .	P. M. 5:20
101.3	22	68	P. M. 12:10	101	20	60	P M 3:00	101.8	16	. .	P. M. 4:45			
100.7	30	60	12:15	101.8	30	. .	P. M. 2:15	101.8	. . . .		4:30	In heat: took bull.		

TABLE IV.

ACTION OF TUBERCULIN ON GRADE SHORT-HORN COW: NEARLY DRY:

Before injection.						After injection.							
Date 1894.	Norm. Temp.	Resp.	Pulse.	Tuberculin Dose.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Nov. 3	Deg. 100.8	. .	. .	28m	A. M. 6:30	Deg. 101.2	20	. .	P. M. 2:00	Deg. 102.3	17	. .	P. M. 4:00
9–10	102.7	. .	. .	29m	P. M. 10:00	104.3	30	72	A. M. 7:00	103.7	22		P. M. 9:15
14–15	101	16	54	28m	P. M. 10 3	101	20	48	7:00	101.7	20	56	A. M. 9:30
22–23	100.6	21	. .	28m	P. M. 10:20	100.8	25	. .	7:00	102	25	54	9:30
28–29	101	16	43	28m	10:15	101.3	20	44	7:00	102	16	48	A. M. 9:15
Dec. 7–8	101.5	22	48	28m	10:30	100.5	23	50	A. M. 7:30	101	22	42	A. M. 10:00
12–13	101.6	30	60	29m	10:30	101.9	18	. .	A. M. 7:15	102.3	17	52	A. M. 10:15

TABLE V.

ACTION OF TUBERCULIN ON GRADE DEVON COW: DRY: FARROW.

Before injection.						After injection.							
Date 1894.	Norm. Temp.	Resp.	Pulse.	Tuberculin Dose.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Nov. 3	Deg. 101.5	. .	. .	28	A. M. 6:30	Deg. 101	18	. .	P. M. 2:00	Deg. 102.3	17	. .	P. M. 4:00
9–10	101.7	. .	. .	27	P. M. 10:00	101.8	24	60	A. M. 7:00	102.1	12	. .	A. M. 9:15
14–15	101.5	18	62	26	P. M. 10:30	102.2	22	48	7:00	102.2	18	50	A. M. 9:30
22–23	100.2	14	.	27	P. M. 10:20	101	15	. .	7:00	102	11	48	9:30
28–29	101.2	11	50	27	P. M 10:15	102	16	42	7:00	101.2	11	42	A. M. 9:15
Dec. 7– 8	101.5	16	60	27	10:30	101.8	23	60	A. M. 7:30	102.3	24	60	A. M. 10:00
12–13	101	13	48	27	10:30	101.7	14	43	A. M. 7:15	101.1	17	48	A. M. 10:15

TABLE IV.

FARROW. AFTER INJECTION.—

Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Deg.			P. M	Deg.			P. M.	Deg.			P. M.	Deg.			P. M.
102 6	. .	. .	5:15	102	21	48	7:00	101.3	13	45	9 00	101.5	42	48	10:15
103.8	17	. .	A. M. 11:20	102.8	18	. .	P. M. 2:00	103	22	. .	P. M. 4:00	101	16	. .	P. M. 6:45
101	18	50	. .	101.5	13	42	P. M. 1:00	101.5	16	54	P. M. 3:00	102	16	54	P. M. 5:00
102	15	60	A. M. 11:30	101.6	18	60	P. M. 2:30	102.4	20	48	P. M. 4 00				
101.9	15	48	A. M. 11:45	101.5	18	52	P. M. 2:00	101.5	16	46	P. M. 4:00	102	. .	. .	P. M. 5:20
101.3	16	58	P. M. 12:10	102	16	52	P M. 3:00	101.6	18	. .	P. M. 4:45				
101.7	18	52	12:15	101.8	23	. .	P. M. 2:15	101.8			P. M. 4:30				

TABLE V.

AFTER INJECTION.—

Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.	Temp.	Resp.	Pulse.	Hour.
Deg.			P. M.	Deg.			P. M.	Deg.			P. M.	Deg.			P. M.
102.6	18	. .	5:15	102.6	14	70	7:00	101.9	14	64	9:00	101.8	15	64	10:15
102.2	11	. .	A. M. 11:20	101.4	16	. .	P. M. 2:00	101.4	14	. .	P. M. 4:00	101.5	14	. .	P. M. 6:45
102.2	12	46	. . .	101.3	14	48	P. M. 1:00	101.7	16	40	P. M. 3:00	101.8	24	48	P. M. 5:00
102	18	44	A. M. 11:30	101.8	18	48	P. M. 2:30	101.5	12	40	P. M. 4:00				
102.2	10	42	A. M. 11:45	101.2	14	48	P. M. 2:00	101	18	46	P. M. 4:00	101	. .	. .	P. M. 5:20
102	16	58	P. M. 12:10	101.8	16	54	P. M. 3:00	101.6	14	. .	P. M. 4:45				
101.3	14	44	P. M. 12:15	101.5	16	. .	P. M. 2:15	101.6	. .	. .	P. M. 4:30				

TABLE VI.

MILK RECORD OF BELVA, FOR THE PERIOD OF THE TUBERCULIN TEST, AND OF TWO OTHER HOLSTEIN COWS IN SIMILAR CONDITIONS APART FROM THE TEST.

	BELVA. Calved Sept. 16th. Lbs.	MOLLY. Calved Oct. 4th. Lbs.	FREDA. Calved Aug. 28th. Lbs.
Oct. 28th,	40.5	39.5	44.5
“ 29th,	39.75	42.25	44.5
“ 30th,	40.5	42.25	44.5
“ 31st,	35 *	37.5	45.25
Nov. 1st,	34.5	40.75	36
“ 2nd,	38.5	42.5	41.75
“ 3rd,	31.5	34.75	40.25
“ 4th,	37	34.75	42.75
“ 5th,	32	33.5	40.5
“ 6th,	36	35.75	41.5
“ 7th,	35.75	37	45.75
“ 8th,	38.25	40.5	47.5
“ 9th,	38	40.5	46
“ 10th,	38	41.25	43.5
“ 11th,	39	41.5	42.5
“ 12th.	36.75	40.75	41.75
“ 13th,	41.25	45.5	45
“ 14th,	41.5	42.25	47
“ 15th.	41.25*	46.5	45.75
“ 16th,	39.5	43.5	42
“ 17th,	40.75	45	43.75
“ 18th,	41	45	43.25
“ 19th,	42.25	48	43.25
“ 20th,	38	42.5	42
“ 21st,	37.75	43	41.5
“ 22nd,	37.25	44.5	37 served
“ 23rd,	38.5 *	43.5	37.75
“ 24th,	37.75	40	37.5
“ 25th,	36.25	38	34.5
“ 26th,	34.25	38.5	35.25
“ 27th,	36.25	41	36
“ 28th,	35	41	36.25
“ 29th,	35 *	41	39
“ 30th,	34.75	41.5 served	41.25
Dec. 1st,	35.5	42.5	42.25
“ 2nd,	33.75	42	41.5
“ 3rd,	35.75	41.5	42.25
“ 4th,	34.75	38.75	40
“ 5th,	38.25	42.25	43.75
“ 6th,	39	42.75	44.75
“ 7th,	38.5	43.75	45
“ 8th,	34.75*	43.25	42.75
“ 9th,	37.25	43.25	42
“ 10th,	37.25	41.25	41.5
“ 11th,	35.75	41.5	40
“ 12th,	34.25	42.25	40.5
“ 13th,	37.25*	43	39.5

* Indicates the 20 hours following the different tuberculin injections.

TABLE VII.

MILK RECORD OF DAISY, DURING THE PERIOD OF THE TUBERCULIN TEST, AND OF ANOTHER JERSEY COW UNDER SIMILAR CONDITIONS APART FROM THE TEST.

DAISY. Calved Sept. 12th. Lbs.	BERTHA. Calved Sept. 17th. Lbs.	DAISY. Calved Sept. 12th. Lbs.	BERTHA. Calved Sept. 17th. Lbs.
Oct. 28, 20.75	29.25	Nov. 21, 18	30
" 29, 20.75	27.75	" 22, 19.25	27
" 30, 22.25	29.75	" 23, 18.5*	26.5
" 31, 21.5*	26	" 24, 17	25.5
Nov. 1, 19	27.75	" 25, 17	26
" 2, 20.25	27.25	" 26, 18	23.5
" 3, 19	26	" 27, 17	23 served
" 4, 20 5	26.75	" 28. 19	23
" 5, 17.25	24.75	" 29, 18*	24.25
" 6, 19.75	24	" 30, 17	23
" 7, 17.75	26.25	Dec. 1, 17	24.5
" 8, 19.5	30.25	" 2, 19	26
" 9, 21	30.25	" 3, 16	25.5
" 10, 19.25*	28	" 4, 17	24
" 11, 17	27.5	" 5, 16	26.5
" 12, 18.5	28.5	" 6, 17	26
" 13, 20	29.75	" 7, 15	28.25
" 14, 19	27.75	" 8, 15*	27.5
" 15, 17.5*	29	" 9, 17	27
" 16, 19.75	32.5	" 10, 15.75	24.25
" 17, 18.25	33.5	" 11, 16.75	26.25
" 18, 19.5	30	" 12, 17	27
" 19, 17.5	30.75	" 13, 15* served	26.75
" 20, 20.5	25.5		

---

* Tuberculin in system, the day following injection.

TABLE VIII.

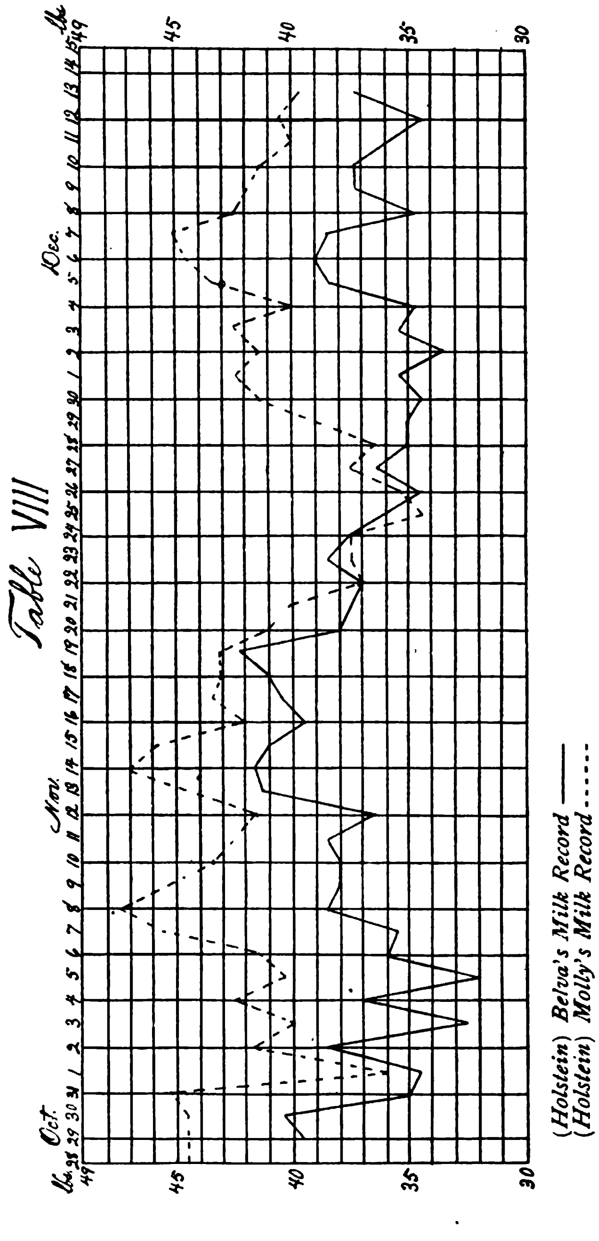
Table VIII
lbs.
49
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Oct.
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Dec.
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14
15
(Holstein) Belva's Milk Record ——
(Holstein) Molly's Milk Record - - - - - -

TABLE IX.

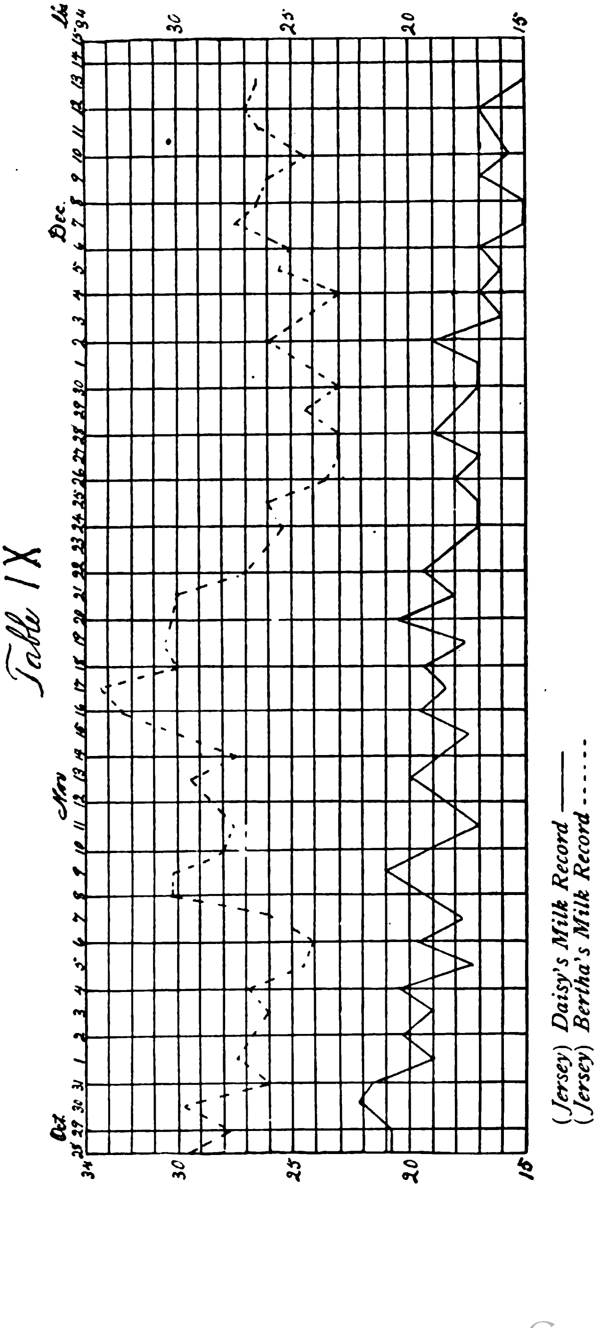
Table IX
Lbs
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Oct.
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15 '94
(Jersey) Daisy's Milk Record ——
(Jersey) Bertha's Milk Record ......

TABLE X.

PERCENTAGE OF BUTTER-FATS IN MILK OF BELVA DURING EXPERIMENT; ALSO IN HOLSTEIN COWS MOLLY AND FREDA NOT INJECTED.

		BELVA.	MOLLY.	FREDA.	
Oct.	20,	3.6 %	4.9 %	3.2 %	
"	27,	2.85%	3.85%	3.5 %	Three days before 1st injection of tuberculin
Nov.	3,	3.2 %	4.25%	3.55%	Three days after tuberculin injection.
"	10,	3.2 %	3.8 %	3.35%	Under tuberculin. Injected night before.
"	17,	3.3 %	3.75%	3 %	Two days after tuberculin.
"	24,	2.9 %	3.65%	3.3 %	One day after tuberculin
Dec.	1,	2.8 %	3.95%	2.95%	Two days after tuberculin.
"	8,	3.4 %	3.4 %	3.1 %	Under tuberculin. Injected night before.

TABLE XI.

PERCENTAGE OF BUTTER-FATS IN MILK OF DAISY DURING TUBERCULIN EXPERIMENT; ALSO OF JERSEY COW BERTHA NOT INJECTED.

		DAISY.	BERTHA.	
Oct.	13,	5.1 %	4.8 %	
"	20,	5.6 %	4.45%	
"	27,	5.1 %	5.05%	Three days before 1st injection of tuberculin.
Nov.	3,	5.3 %	5.05%	Three days after tuberculin injection.
"	10,	5.5 %	5.3 %	Under tuberculin. Injected night before.
"	17,	5.5 %	5.4 %	Two days after tuberculin.
"	24,	5.4 %	4.25%	One day after tuberculin.
Dec.	1,	5.05%	5.1 %	Two days after tuberculin
"	8,	4.9 %	4.85%	Under tuberculin. Injected night before.

TABLE XII.

PERCENTAGE VARIATION IN THE CONSTITUENTS OF THE MILK OF HEALTHY COWS UNDER A TEST DOSE OF TUBERCULIN.

Animal.	Date.	Total solids.	Sugar.	Albuminoids.	Fat.	Ash in milk.	Acidity. Lactic acid.		
No. 113,	Mar. 31,	11.01	4.17	3.26	2.54	.775		Before	injection
" 113,	Apr. 1,	10.69	3.84	3.20	1.52	.696		After	"
" 217,	Mar. 31,	10.83	4.17	2.96	2.23	.723		Before	"
" 217,	Apr. 1,	10.38	4.16	2.89	2.54	.700		After	"
" 217,	" 12,	11.03	4.17	1.26	2.56	.681		Before	"
" 217,	" 13,	9.77	3.57	1.39	1.53	.727		After	"
" 217,	May 31,	12.03	4.16	2.82	2.43	.711		Before	"
" 217,	Jun. 1,	10.25	4.16	2.29	1.27	.666		"	"
" 217,	" 5,	11.26	4.16	2.70	2.03	.688	.176	After	"
" 217,	" 11,	11.97	4.16	4.17	2.03	.590		No	"
" 217,	" 12,	10.82	4.16	3.83	1.52	.692		"	"
" 217,	" 13,	11.30	4.16	3.97	2.02	.751		"	"
" 217,	" 15,	11.62	4.16	4.25	2.03	.767		"	"

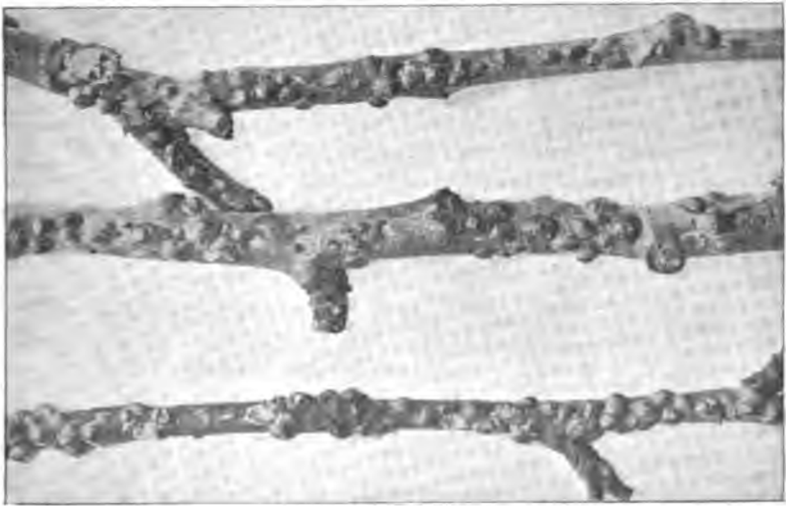
Bulletin 83. December, 1894.

Cornell University Agricultural Experiment Station,

ENTOMOLOGICAL DIVISION.

A PLUM SCALE

IN WESTERN NEW YORK.



By M. V. SLINGERLAND.

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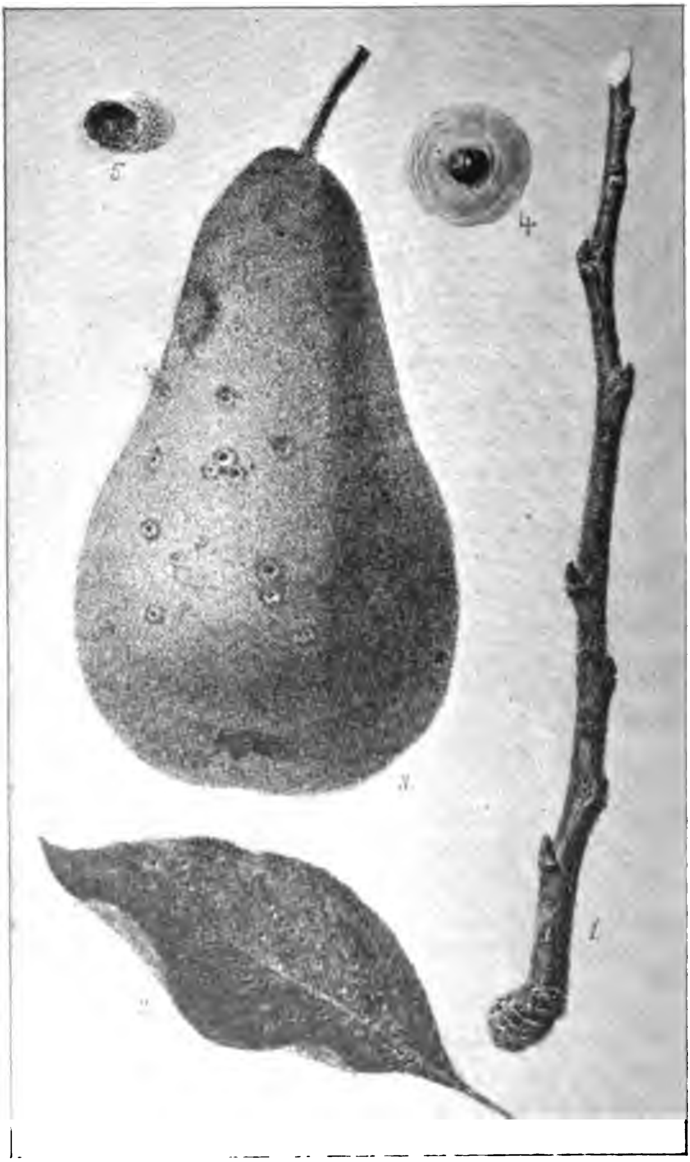
62. The Japanese Plums in North America.
63. Co-operative Test of Sugar Beets.
64. On Certain Grass-Eating Insects.
65. Tuberculosis in Relation to Animal Industry and Public Health.
66. Test of Cream Separators.
67. Some Recent Chinese Vegetables.
68. The Cultivated Poplars.
69. Hints on the Planting of Orchards.
70. The Native Dwarf Cherries.
71. Apricot Growing in Western New York.
72. The Cultivation of Orchards.
73. Leaf Curl and Plum Pockets.
74. Impressions of the Peach Industry in Western New York.
75. Peach Yellows.
76. Some Grape Troubles of Western New York.
77. The Grafting of Grapes.
78. The Cabbage Root Maggot, with notes on the Onion Maggot and Allied Insects.
79. Varieties and Leaf-Blight of the Strawberry.
80. The Quince in Western New York.
81. Black-Knot of Plums and Cherries, and Methods of Treatment.
82. Experiments with Tuberculin on Nontuberulous Cows.
83. A Plum Scale in Western New York.

CORNELL UNIVERSITY, ITHACA, N. Y., Dec. 20, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY.

Sir: Probably the most serious enemy which has appeared in New York orchards in many years is a scale insect, which attacks plums and some other trees. It is not known how long the insect has been a resident of the state, but it has not attracted the attention of orchardists until within the last year or two; yet even now it threatens the entire destruction of thousands of trees in the counties of Niagara, Monroe and Ontario. The full life history of the insect is not yet understood and its scientific name is not determined; but Mr. Slingerland has made a careful study of it during the summer and has discovered enough of its characteristics to enable him to give competent advice for its destruction. It can be destroyed by persistent spraying between now and spring. This bulletin is essentially a report of progress in the study of this scale, and in order to aid the reader in distinguishing it from the San José scale, which has recently appeared in the state, an illustration of the latter insect is inserted. The bulletin is approved by Professor Comstock. The whole account is submitted as a bulletin in compliance with Section 87, Chapter 675, of the laws of 1894.

L. H. BAILEY.



THE SAN JOSÉ SCALE.

1, Infested branch; 2, infested leaf; 3, pear, bearing a few of the scales; 4, female scale—enlarged; 5, male scale—enlarged. (Adapted from report of W. G. Klee, 3d Rept., Cal. Bd. Hort.) Inserted for comparison with the western New York plum scale, described in the following pages.

A PLUM SCALE.

Lecanium sp.

Order Hemiptera; family Coccidæ.

Heretofore, the scale insects have played but a very small part in the havoc annually resulting from the attacks of insect pests in the northern and eastern parts of the United States. In the extreme western (California) and southern (Florida and Louisiana) states, however, most of the energy expended by fruit growers in combating their foes has to be directed against this class of insects, which there take first rank as pests. But, during the past year, two scale insects appeared in such numbers in some of the northern and eastern states as to greatly alarm fruit growers. One of these is the dreaded San José Scale (*Aspidiotus perniciosus*) of California, which has recently appeared in our state, especially on Long Island. Figures of this pernicious scale are given on the preceding page to familiarize fruit growers with its appearance, and also more especially for comparison with those of another scale which now threatens the plum industry. This latter scale has doubtless been present in eastern plum orchards for years, apparently awaiting certain conditions that seem at last to have occurred in certain localities, but more especially in western New York.

The past year, several of the largest and finest plum orchards in our state have suffered severely from this plum scale. In one orchard of over 2000 trees, one fourth of the immense crop was not worth picking and most of the remainder was badly damaged. But still more alarming than this is the fact that there are more than 50,000 of the best plum trees in western New York, which, at the present moment, are harboring millions of these scales; and unless these are destroyed this winter or in the spring, they will literally overrun these trees with such dire results as we scarcely dare predict. In short, the indications are that if this pest is allowed to begin work in full force in the spring of 1895, it will soon ruin some of the finest plum orchards in the state.

Our study of this new pest has not progressed far enough to enable us to present a complete account, but fortunately the work has reached a stage when we can confidently recommend an effective method for checking the insect before another season opens. We feel that the gravity of the situation demands that the fruit growers be made acquainted at once with the facts already learned.

THE INSECT'S APPEARANCE.

Fortunately, the larger, conspicuous, brown, dead scale or shell of the mature female insect is present on infested rees during the whole year, thus enabling fruit growers to tell at any time whether the pest is in their orchards or not. The illustration on the front of this bulletin shows many of these dead scales natural size as they appear on the branches. They are very conspicuous objects, as the figure shows, and may be easily found and recognized wherever they occur. They remind one of small halved peas colored dark brown and stuck on the branches. Beneath these dead scales the bark presents a white scar of the exact shape of the outline of the scale; these spots remain white for a long time after the scale is removed.

In April and May the living female insects resemble the dead scales shown in the figure on the title page, but they are soft to the touch and often striped with yellow. In June, after egg-laying has ceased, they become firm, smoother, lose their yellow markings, and are then simply a dark brown shell. If this shell be then turned over, it will be found full of the minute white eggs of the pest. After July 15, the dead scales contain nothing but a white dust consisting of the empty egg shells. Although these brown shell-like remains of the mother insect persist on the branches throughout the season, or even for a year or more, they are no longer a menace to the tree. They occur most numerously on the undersides of the branches of the preceding one or two year's growth.

Should a fruit grower find these large dead brown scales one half as thick on his plum trees as they are shown in the figure, he may be quite sure that there is also an alarming crop of the young scales now in hibernation in similar localities on the trees.

When the large shells are found, closely examine the bark in their vicinity for minute, very flat, spindle-shaped, dark brown scales. Many of these are shown, natural size, on the plum branch in figure 1; when these young scales occur as numerously as shown in this figure, they are easily seen in the winter. It is this stage of the insect that now portends danger to some of the best orchards in the state. They are to be found snugly tucked away into almost every crevice on the trees from the trunk near the ground to the topmost twig. How they got there, and what they will do in the spring (they are now doing no harm) is discussed further on under the life history of the pest. The male insect is also discussed under the same heading.

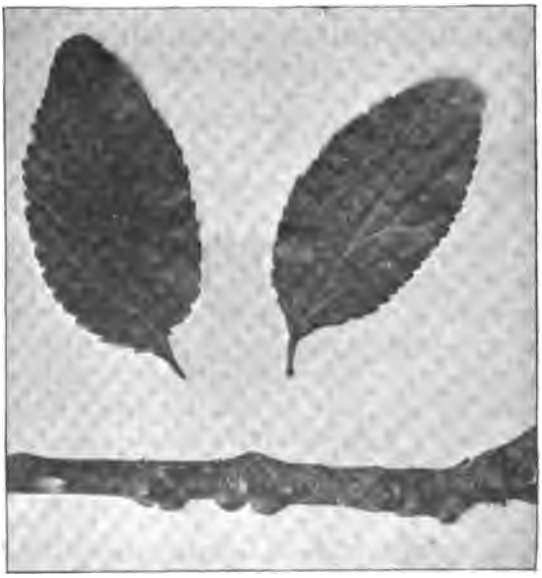


FIG. 1.—*Plum branch containing many young scales in hibernation near the large mother-shells; and plum leaves with many of the young scales along the veins, as they appear in summer. All natural size.*

ITS NAME.

This plum scale is allied to the well-known Mealy Bugs on green house plants, to the Oyster-shell Bark-louse so common on some unhealthy apple trees here in the east, and to the very destructive San José Scale recently introduced into our state. However, the pest belongs to a different group of the scale insects known as the Lecaniums; several species of Lecaniums are serious pests in California orchards. As this difficult group has received comparatively little attention from systematic workers in etomology, it is not easy to definitely decide whether a Lecanium found on a certain plant is new to science or is a species which received a name years before. This plum scale has been in the hands of experts for several months, but different opinions still prevail as to what it shall be called. It is probably some European species described a half century or more ago. *

THE DISTRIBUTION, DESTRUCTIVENESS, AND PAST HISTORY OF THE INSECT.

The present uncertainty regarding the name of this Plum Scale makes it impossible to draw any definite conclusions about its history, distribution, or destructiveness previous to 1894. However, we believe it is an European insect which has been present in eastern plum orchards for many years. A careful examination of several orchards which were apparently free from the insect, revealed the scales scattered here and there on the trees, sometimes not more than one or two on a tree. Certain conditions, perhaps climatic or possibly the presence of many active enemies, seem to have thus far held the insect in check in a majority of orchards. While in other localities, especially in the counties of Niagara, Monroe, and Ontario in our state, certain unknown conditions have favored the increase of the pest during the past three

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* Mr. T. D. A. Cockerell, who has given considerable study to this group of scales, concludes that the pest is the Butternut or Walnut Scale (*Lecanium tuglandis* Bouché) with which Dr. Fitch's *L. juglandifex* is synonymous ("The Entomologist" for December, 1894). There is a Lecanium, which is quite common on butternut in our state, that is very closely allied to if not indentical with, this Plum Scale; but no butternut trees occur near some of the worst infested plum orchards. The pest may be identical with Dr. Fitch's *L cerasifex* described in 1856, but this scale has not been again recognized since it was described, so the identity of the two scales could not be definitely established. Mr. L. O. Howard, U. S. Entomologist, writes us, under date of December 17, 1894, that "the most careful studies I have made have failed to lead me to any definite conclusion, beyond the fact that I feel sure the species is not Fitch's *juglandifex*. I simply drop the whole subject for the present, pending the receipt of specimens of the European species from Mr. Douglas." Perhaps this western New York Plum Scale has not yet been christened, who shall say?

or four years, until it has now reached a point where it threatens the destruction of some of the finest orchards in these counties.

We have found but a single reference to a Lecanium attacking plum trees in the east prior to 1894. In 1866, a correspondent in Vermont sent a plum branch containing many of the scales to Mr. Walsh, then editor of the "Practical Entomologist" (p. 89 and 100), for identification. Mr. Walsh's notes on the eggs agree so closely with our observations on the Plum Scale this season as to indicate that the Vermont scale was the same insect. Recently, Miss Murtfeldt (Bull. 32, Div. of Ent. of the U. S. Dept. of Agr., p. 41–44) has recorded the appearance in destructive numbers in 1893 of a Lecanium on plum and peach in Missouri. This Missouri Plum Scale seems to differ slightly in some of its characteristics and in its life history from our New York Scale, but may not the difference of 5 degrees in latitude between the two localities account for these differences between the insects? Mr. Fletcher recently found a Lecanium, probably identical with our New York species, on plum at Queenstown, Canada.* Thus, while we believe that this new plum pest occurs in many orchards outside our state, no definite conclusions can be drawn from the meagre and indefinite evidence thus far reported.

We have also received the insect from Utica and from Prattsburg (Steuben Co.) N. Y., but it has not yet become serious in these localities. The only localities, so far as we know, where the pest is now present in alarming numbers is in several of the large orchards near Geneva, Rochester, and Lockport. Nearly all of the owners of these orchards are thoroughly alive to the necessity of checking this pest at once, and the work of extermination has already begun in some of the orchards.

How long the insect has been present in these localities, is not known. It was seen in considerable numbers in Geneva orchards

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*Mr. Cockerell will describe this scale as *L. rugosum* in the coming Februrary number of the "Canadian Entomologist." He says it agrees closely with the New York Scale in microscopic characters, but differs slightly in form. The form of these scales depends so much upon the time when they are collected and killed, whether they are crowded together on the branch or not, and other factors that the mere form of the dead females or their shells does not furnish a sure criterion by which to determine the names of many of the Lecaniums.

four or five years ago. We saw it at Lockport in 1893, but as no such scale had before ravaged fruit trees in the east, we did not anticipate any such injury as the pest wrought in this orchard this year.

The destruction wrought by this scale the past summer has been considerable in most of the orchards mentioned above. One fourth of Mr. Hooker's crop from over 2000 trees was so badly damaged that it was not picked at all, while the remainder was more or less dwarfed or presented a smutty appearance. Much of the fruit in these orchards either had to be washed or sent to the market in a "mussy" condition. Many bushels of plums were also "under-size." Thousands of trees made but little growth during the season, and from present indications it would seem as though some of these orchards must succumb in the near future unless this insidious foe is soon checked.

INDICATIONS OF ITS PRESENCE.

One form of the insect itself is so conspicuous, as shown in the figure on the title page, that it may be discovered before it has made its presence felt by any visible effect on any part of the tree. This year, in the worst infested orchards, the trees showed scarcely any visible signs of the presence of the pest until July. During this month the young scales hatched and went onto the leaves and fruit stems where they at once began sucking the sap. So many thousands of these little pumps at work drawing out the sap soon began to tell on the vigor and health of the trees. In consequence, many of the leaves curled considerably, and the trees made but little growth.

But the most noticeable indications of the presence of the pest was caused by the immense quantities of a clear, sweet, sticky liquid known as "honey dew" which the little scales secreted in July and August. A black fungus always accompanies this honey dew, growing in and spreading all through it; and as the sticky fluid was secreted in such quantities as to literally cover the whole tree, the consequence was that badly infested trees presented a disgusting black appearance, as if treated with a thin coat of a sticky smutty substance. This blackened honey dew covered the leaves, doubtless closing up many of their breathing pores, and gave to the fruit a smutty or "mussy" appearance. The loss of so much sap also dwarfed much of the fruit. Thus a badly infested orchard presents a sorry sight in August, with its stunted growth, curled leaves, and dwarfed fruit, while the whole tree has a disgusting smutty appearance. During the winter these conspicuous blackened trees are unwelcome monuments of the work of the pest during the summer.

Those who have seen the effects of the Pear Psylla on pear trees will at once recognize a plum tree which has suffered from this Plum Scale. Trees attacked by either insect present the same black unhealthy appearance, but the Pear Psylla does not attack the plum, nor does this Plum Scale seem to have yet appeared in destructive numbers on the pear.

ITS FOOD-PLANTS.

This scale is as yet *par excellence* a plum pest; and we have not seen it on plum trees less than five years old. However, many quince trees near infested plum orchards suffered severely last summer from what appears to be the same insect; and we have just received an apple branch from Lewiston, N. Y., which bears several similar scales with other indications that the tree has suffered considerably from the insect. It was doubtless the same insect which we saw on a pear branch that projected into an infested plum tree. An elm branch on which were seen many scales doubtless became infested from a plum tree near by. Mr. Hooker reports a similar scale on his honey locust hedge. And Mr. Beach says ("Garden and Forest," July 18, 1894, p. 284) the insect has been found on apple, pear, maple, and *Cissus*. In one orchard, apple and cherry trees in rows alongside infested plum trees have but very few of the scales, while quinces near by are freely attacked. Thus the pest apparently thrives on quince, and may attack apple, pear, cherry, elm, maple, honey locust, and *Cissus*.

We doubt if the pest has any preferences among the cultivated varieties of plums. In one orchard, Smith's Orleans suffered the most, while in another Copper, Bradshaw, and Lombard were the worst infested. The scales are also now present in one orchard in alarming numbers on Damsons, Reine Claude de Bavay, Quackenbos, and on Prunes. The Japanese varieties have not yet been attacked, so far as we have learned.

THE LIFE HISTORY OF THE INSECT.

Its first appearance and habits in the spring.—As previously stated, the old shells of the female insects are to be found on the trees at any time of the year, but as they no longer play any part in the economy of the insect, they need not be considered in this connection. It is only the small, flat, spindle-shaped, brown scales that need attention early in the spring; these are shown natural size on the branch in figure 1, and also on the portion of board shown in figure 4, where they are scattered among the large spiny skins of a Lady-bird larva. About April 1, or even earlier, these little scales begin to move about on the tree; they are seeking a suitable place to establish themselves. This they usually do on the undersides of the smaller branches. Once established, most of them probably never move from the spot. Each scale inserts its little beak or sucking organ into the bark, and for nearly two months each of these minute pumps is kept constantly at work drawing out the sap.

Remarkable growth of the scales in the spring.—As these little scales have had their appetites whetted by over five months of fasting, their little pumps seem to work with surprising vigor in the spring. The result is that they increase in size remarkably fast. In less than two months last spring, most of the little scales, only 1 mm. (.04 of an inch) in length, grew to the size of the scales shown on the front of this bulletin. Doubtless the scales secrete considerable quantities of honey dew during this period of rapid growth.

Many of these little scales, however, do not grow into these large conspicuous females. But after feeding for a short time, their skin is cast off and it forms a thin, delicate, semi-transparent, whitish, ribbed scale or shell over the pupae; beneath this cast skin the male insect develops. The males are very delicate in structure, and each is provided with two large whitish wings. At *m* in figure 2 are shown several of these male scales considerably enlarged; from the lower end of the two upper scales the tips of the wings of the male insect protrude, and in one instance the two long white filaments which project from the end of the insect's abdomen can be distinctly seen extending considerably beyond the wings. At *n* in the figure, a male scale and a female scale are shown natural size, the one on the right being the male. The male scale is thus much smaller, flatter, more elongate, and is of a whitish color. They often occur in considerable numbers among the large brown female scales in May and June. They are rarely seen after June, as they do not adhere strongly and thus soon "weather off." The males doubtless emerge in May, but probably live only long enough to mate with the then mature females. In their early stages, the male scales are scarcely distinguishable from the young females.

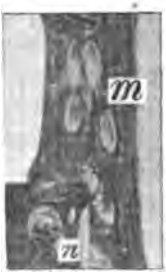

FIG. 2—m, *male scales, enlarged*; n, *male scale and female scale, natural size.*

The eggs.—This year, by the 18th of May many of the female scales had become full grown. And by tipping them over at this time, it was found that egg-laying had just begun. The female lays her eggs under her own body. During the process, her outer skin hardens and her body gradually shrivels thus making room underneath for the eggs. Egg-laying continues for a week or ten days, and, what was at the beginning a large fleshy soft-bodied female, becomes, when the task is finished, only a thin hard shell closely adhering to the branch and containing a mass of embryonic life in the form of minute white eggs. If one of these shells be disturbed in June, it will be found packed nearly full of eggs, which roll out when the shell is tipped as represented in figure 3. In this figure the scale is shown considerably enlarged, but at *n* in figure 2, is another view of the same scale natural size.

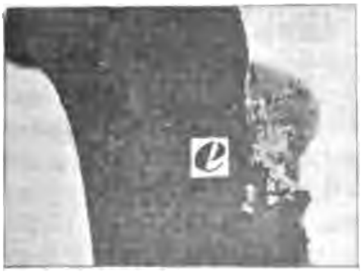

FIG. 3—e, *eggs as they roll out from beneath a mother-shell in June; enlarged.*

This year the egg stage lasted about a month, the eggs becoming pinkish in color about a week before they hatched. Some of the minute active scales emerged as early as June 23, but most of them appeared about July 1. The little creatures remained under the protecting shell for several hours, some of them a day or more, before venturing forth onto the branches. Thus if one of these mother scales is overturned in the latter part of June, it may contain hundreds of the active little creatures and as many more eggs yet unhatched.

The number of eggs laid by a single mother is enormous, reaching into the thousands. We have not counted them under one of these Plum Scales, but others have counted 1054 and 2200 under similar scales of other species of Lecaniums.

The young at last venture forth from under the shell, and about July 1 may be seen actively crawling about on all parts of the tree. The old mother shells which they have left contain nothing but a whitish powder made up of minute egg-shells.

Habits of the young scales in summer.—Soon after emerging from the old shell of their mother, the little scales find their way onto the leaves. Here they usually establish themselves close beside the veins on the underside, some take up similar positions on the upperside, while others attach themselves without regard to the veins. In figure 1 is shown the young scales, natural size, thus attached to the leaves. Although there are many more scales on the leaf at the right, they are so nearly the color of the underside of the leaf that they do not show as distinctly as those on the leaf at the left. Practically all of the newly-hatched scales thus established themselves on the leaves, or leaf and fruit petioles, in July. The scales are then so small, scarcely .5 mm. (.02 of an inch) in length, so flat and closely pressed to the leaf, and so near the color of the undersides of the leaves that they can hardly be distinguished without a lens. In some of the worst infested orchards, nearly every leaf bore hundreds of these little scales. With so many millions of little pumps at work on a single tree sucking the sap, is it any wonder that many trees made but little growth and that much of the fruit was dwarfed?

Through the kindness of Mr. C. M. Hooker, who sent us infested leaves from time to time during the summer, we were able to follow the life-history of the pest closely. The little scales moved about but little, if any, during the summer; and also grew exceedingly slow as compared with the surprisingly rapid growth of their mothers in the spring. In a month the little creatures had gained scarcely .1 mm. (.004 of an inch) in length, and yet they had already caused many of the leaves to curl, the fruit began to show their effects, and the trees presented a smutty disgusting appearance. The amount of honey dew secreted by each individual scale was doubtless very small during the two months (July and August) that they worked on the leaves. But the aggregate from millions of the little scales was sufficient to completely coat the trees, including their leaves and fruit. The pest did more damage this year while in this young stage on the leaves than at any other period of its life.

Fall migration.—August 21, Mr. Hooker wrote us that some of the scales "were on the march." It was found that they were moving to the undersides of the branches where there were still many of the old shells of their mothers from which the little scales had emerged more than two months before. This migration continued until most of the leaves had fallen; probably a majority of the scales had established themselves on the branches by October 1. Most of them sought the undersides of the smaller branches, and in many instances they were to be found in these places in such numbers as to form two or three layers of scales on the bark. Thousands of them, however, crawled into any sheltering crevice on large or small limbs or even on the trunk of the tree. Figure 4 shows how thickly they congregated on the underside of a small piece of board placed under a rope to protect the bark; the large spiny objects on the board are the pupae of a Lady-bird beetle, one of the enemies of this scale described farther on.

In August, the scales became light brown in color, and this deepened into a dark seal brown when the migration began.

Some of the scales did not migrate to the branches this fall. From material sent us by Mr. Hooker, we estimate that about 10 per cent. of them fell to the ground with the leaves. Many of these will doubtless find their way to the trees again in the spring.

Hibernation.—When the scales migrated from the leaves to the branches, they measured about 1 mm. (.04 of an inch) in length, or were only about twice as large as when they hatched and went onto the leaves in July. These small dark brown scales are at present on the trees in the position to which they migrated in September. They will doubtless pass the winter in this stage, without feeding. Many of these hibernating scales are shown in figure 1; they lie scattered about on the plum branch among a few old mother shells.

It is to these hibernating scales that we referred when we stated on a preceding page that there are at the present moment more than 50,000 of the best plum trees in western New York, each of which is harboring millions upon millions of this Plum Scale. Fortunately, these hibernating scales are tender creatures, and most of them lie exposed on the bark of the trees. Thus this stage is the weakest point in their life history, and fruit growers must take advantage of it this winter. For, as we have shown above, these little creatures grow with astonishing rapidity early in the spring and soon get beyond man's power to check them by any practicable means.

Number of broods.—There is but one brood in a year. The little scales now in hibernation develop into full grown males and females in May. Eggs are soon laid, and this stage lasts nearly a month. About July 1, the young scales emerge and migrate to the leaves where they remain for two or three months, scarcely doubling in size meantime. In September these scales again migrate, going onto the branches where they hibernate.

HOW THE INSECT SPREADS.

As the pest is not very active in any of its stages, it doubtless would spread very slowly if left to itself. At certain seasons, however, especially when the young scales are migrating in July and September, many of them doubtless become attached to the feet of birds that may then visit the trees. The scales could be carried long distances in this way.

The young scales may also attach themselves to larger insects which frequent the trees. Last year, in Maryland, several Lady-bird beetles and ants were seen bearing one or more young of the San José Scale on their backs; curiously enough, the scales seemed to prefer to ride on the backs of the shining black beetles and ants rather than on the red ones.

Doubtless the wind is an important factor in the spread of this pest. Possibly a strong wind may detach some of the scales and carry them to other trees. The wind also distributes the fallen leaves over a considerable area in the fall; and as many of these leaves contain a few hibernating scales, they would form a fruitful source of contagion. We estimate that about 10 per cent. of the scales are hibernating on these leaves, and many of them will doubtless find their way onto the nearest trees in the spring.

Is there danger of introducing it on nursery stock?—Some newspapers, in commenting on our recent popular discussion of this scale in the *Rural New Yorker* and other papers, have warned their readers to carefully examine all nursery stock sent out by New York nurserymen lest the scale be introduced into their orchards in this manner. This is a very important point, and was made the subject of special investigation and inquiry in our recent trip through the infested region. The result is that, so far as we now know, there is but little danger of introducing the pest into new localities on nursery stock. Nurserymen rarely have the stock more than two years, and it is not usually grown near plum orchards. And furthermore, we have never seen or heard of the scale on any except bearing trees. We have not found it on trees which have been set less than five years in orchards. It is always a wise precaution, however, to examine thoroughly all nursery stock for scales or even borers. You need not expect to find this Plum Scale, but remember that the dreaded San José Scale is abroad in the east and may be introduced on nursery stock. Dig out the borers and dip the trees in a strong kerosene emulsion to kill the scales.

ITS NATURAL ENEMIES.

This Plum Scale doubtless has several insect enemies, but we have met with only two thus far. In May, there were many small, narrow, smooth, elevated, black scales scattered among the nearly full grown females. Some of these small black scales can be seen on one of the branches in the figure on the title page. A close examination showed that these scales contained parasites; which we did not succeed in breeding. The parasite is probably a minute four-winged hymenopterous fly which lays her eggs in the young scales, perhaps in the fall. The percentage of the scales thus destroyed this year was not great, but this little foe may become a valuable ally in checking this pest in the near future.

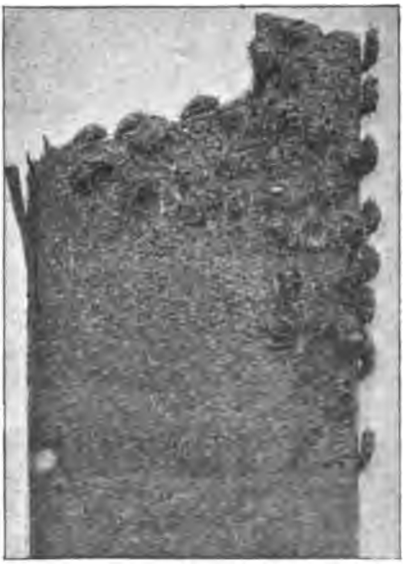

FIG. 4.—*Spiny larval skins of Lady-bird Beetles; and many young plum scales in hibernation. Natural size.*

In figure 4 is shown the spiny larval skins, many of them containing pupae, of the twice-stabbed Lady-bird beetle (*Chilocorus bivulnerus*) which is very common in some infested plum orchards. We have seen hundreds of the spiny skins in groups about the trees, but have not observed the Lady-bird at work on the scales. One of the beetles is just emerging from one of the pupae in the figure. It is a small beetle, about as large as and shaped somewhat like one of the shells of the Plum Scale. But it is of a shining black color and has a bright red spot on each wing cover. This Lady-bird is very common throughout the country, and is said to be the most effective enemy of scale insects in Florida. Both the beetles and their spiny larvæ feed upon the scales. Protect these little friends.

There are doubtless other Lady-bird beetles that are predaceous on this plum scale, and perhaps other true parasites are at work upon it. But the balance of nature seems to have tipped decidedly in favor of the scale at present in western New York, yet these little foes will materially aid in restoring the equilibrium in the future.

HOW TO COMBAT THE SCALE.

What to use.—This pest obtains its food from the inner tissues of the tree by means of its sucking mouth-parts. Thus none of the poisonous insecticides used to kill biting insects would have any effect on this Plum Scale. It must be hit by some of the insecticides that kill by contact. The one that is the simplest to make and which has been found the most effective here in the east against scale insects is the Kerosene Emulsion.* If the directions are carefully followed there is no trouble in getting a good emulsion. This standard emulsion should always be diluted before it is applied to growing plants. But the number of times it is to be diluted, will depend upon the insect to be killed. The nymphs of the Pear Psylla, for instance, are readily killed by a spray consisting of 1 part of the emulsion to 20 parts of water. For most sucking insects it is diluted with 9 parts of water. But our experiments indicate that this Plum Scale does not readily succumb unless the emulsion as made by the formula is diluted with only about 4 parts of water. That is, to one gallon of the standard emulsion is to be added 4 gallons of water. A greater dilution than this cannot be depended upon to do sure work. There is not the slightest danger of this dilution of the emulsion causing any injury to the tree, even when the leaves are opening in the spring. Do not expect to kill a majority of the scales if you dilute it with 7 or 8 or more parts of water.

When to spray. — Between May and October, there is only one period, of less than a week, in which the insect can be combated effectively and practicably. Our experiments indicate that in May the fast maturing females are not susceptible to the emulsion unless it is used so strong as to injure the foliage. The eggs are also safe under their mother's shell during June.

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*To make the emulsion, thoroughly dissolve one-half pound hard or soft soap or whale oil soap in one gallon boiling water. While this solution is still very hot add two gallons of kerosene and quickly begin to agitate the whole mass through a syringe or force-pump, drawing the liquid into the pump and forcing it back into the dish. Continue this for five minutes or until the whole mass assumes a creamy color and consistency which will adhere to the sides of the vessel, and not glide off like oil. It may now be readily diluted with cold rain water, or the whole mass may be allowed to cool when it has a semi-solid form, not unlike loppered milk. This standard emulsion if covered and placed in a cool dark place will keep for a long time. In making a dilution from this cold emulsion, it is necessary to dissolve the amount required in three or four parts of boiling water, after which cold rain water may be added in the required quantities.

However, the newly-hatched scales which emerge about July 1, can be easily killed with the emulsion diluted even 6 or 8 times. But the application must be made while the scales are moving about on the branches; for if they once get established on the leaves, it will be impracticable to hit a majority of them. By tipping over some of the scales every day or two during the latter part of June, one can tell with a lens when a majority of the scales have emerged. When they have done so, do not wait a moment, but completely drench the trees with the emulsion diluted 6 or 8 times. We visited an orchard in July after the scales had become established on the leaves. Nearly every leaf bore hundreds of the little creatures, but it was evident that man was powerless so far as checking them with a spray was concerned. It would have been necessary to literally drench the undersides of every leaf, an impracticable task with a spray. Nothing but the expensive gas treatment with tents, so commonly used in California, would have been of any practicable use. Thus, the pest cannot be effectively and practicably checked by sprays while it is on the leaves from July 1 until the leaves fall in October. Unless the expensive gas treatment can then be resorted to, fruit growers will be obliged to stand idly by in the summer and see the pest do its most damaging work.

Fortunately, however, the scales grow but little during the summer, and then migrate to the branches where they go into hibernation in a tender stage. Therefore, after the leaves fall in autumn, afflicted fruit growers may begin the work of extermination. The little tender scales are then exposed on the undersides of the branches and in crevices all over the tree. There are then no leaves to bother, and every scale that is hit with the emulsion dituted 4 times, speedily dies. Do not expect to see the scales drop off immediately, or even for several days after spraying. It is difficult to tell a dead scale from a live one. If the branches are brought into a warm room and the scales examined closely with a lens after a few days, life can be detected in the uninjured scales. Dead scales are usually of a distinctly lighter brown color and are somewhat shriveled in appearance; where large numbers of dead scales occur near each other, this difference in color is easily seen with the naked eye. Doubtless many of the dead scales will "weather" off by spring.

Under our directions, millions of these scales were killed in some of the infested orchards in November. Other orchardists are now carrying on the work of destruction. Nearly all who suffered from the pest last summer realize the necessity of checking the insect before spring opens. The spray will be equally effective if applied at any time between November 1 and April 1, or when the trees are leafless. There is no question about the effectiveness of the emulsion diluted 4 times, but it must be remembered that each scale must be *hit* with it before it will be destroyed.

How to spray.—Thoroughness must ever be the watch-word in applying the emulsion. The scales are very small objects and you must hit them with the emulsion. In making the application about July 1, the only direction needed is to thoroughly soak the trees with the emulsion. In combating the hibernating scales on the leafless trees, however, more care must be taken in directing the spray. Remember that most of the scales are on the undersides of the smaller branches, but there are thousands of them also in the crevices of the bark all over the tree from the base of the trunk to the topmost twig. Thus in order to hit the scales, the spray must be directed from beneath the tree on all sides, and every crevice filled with the liquid. Drench every square inch of the bark. Do not trust the work to some one who does not appreciate the necessity of hitting every scale, or the work will not be half done.

The McGowen and Vermorel nozzles will do the best work. The knapsack pumps are practicable if but a few trees are infested. But in the large orchards in western New York that are now full of the scale, large tanks and strong pumps must be used. The horse power sprayers will not prove nearly so effective in fighting this pest as an ordinary hand pump and barrel or tank apparatus. You have got to stop at a tree, get under it, and stay at least a minute to do a thorough job. Remember where the scales are that you want to hit and do not leave the tree until they are hit. This idea of thoroughness cannot be too strongly impressed on the one who holds the nozzle when this pest is being fought.

Number of applications.—Not one fruit grower in ten will kill half of the scales with the first application of the emulsion. And yet it is only a question of taking the time to do the work thoroughly enough. Fortunately, you have nearly six months in which to do a thorough job. If possible, get in one blow at the pest before winter closes in. Then be ready to strike again whenever the weather is suitable during the winter. And get in another blow early in the spring before April 1. In other words, spray with the emulsion diluted 4 times, at least once in the fall, once during the winter if possible, and once or twice in March; two very thorough sprayings, may suffice in some orchards. To owners of badly infested orchards who failed to get in a blow this fall, we would say, do not let a suitable spell of weather pass this winter or in March without drenching your trees with the emulsion. We are not putting the case too strongly; for if 25 per cent. of the scales, that are now to be found on 50,000 of the best plum trees in our state, are allowed to develop in May, 1895, these trees will be literally overrun with the pest before the year ends.

The cost.—The Kerosene Emulsion is the most easily made and the cheapest of the insecticides used against sucking insects. The Lime, Salt and Sulphur Wash is not so effective, and the Resin Wash is more troublesome to make. Fruit growers who sprayed this fall, bought kerosene for 4½ cents, per gallon, and soap for from 3½ to 8 cents. per pound; the soap is a small item in any case.

One man made 125 gallons of the diluted emulsion (diluted four times) for $1.12, with soap at 8 cents per pound. With this 125 gallons, 80 trees were sprayed in 40 minutes. Another man sprayed 8000 trees with the emulsion diluted only twice at a total cost for labor and material of less than $70. The work in the latter case was done with horse power sprayers, but not nearly so many scales were killed as in the former case where more than four times as much liquid was applied to each tree.

The labor necessary to do thorough work will cost about as much as the materials used. So that, on an average we believe that one thorough application can be made to a tree 10 or 15 years old for a total cost of not over 3 cents. This may seem a large expenditure to a fruit grower with several thousand badly infested plum trees. But let him recall how much time and money have been put into those trees to bring them to their present condition, and also then realize that unless this pest is soon checked it means the ruin of his orchard in the near future. Every tree could be drenched with the emulsion a dozen times for less than one-eighth of the money that is realized from one good crop from the tree. No time should be lost in trying to devise some way of checking this pest with little expense. The insect is now present in full force and drastic measures are necessary. Every day's delay in trying to save a penny, means dollars of loss next year if the pest gets the start of you in the spring.

Briefly summarized, the way to combat this pest is to spray the infested trees several times, at least twice, this winter or before April 1 with kerosene emulsion diluted with four parts of water. Always bear in mind that each little scale must be hit with the liquid. Do not let the pest get started in force in April. If it does, you cannot fight it effectively until about July 1. Then the young are hatching and while they are wandering about on the branches for a few days, they can be successfully destroyed by the emulsion diluted even six or eight times. If these young scales get established on the leaves in July, they will be beyond your control with a spray until November. You will be helpless against their ravages during the summer months. But the moment the leaves fall, begin the work of destruction on the tender hibernating scales then exposed on the bark. Thoroughness must be the watchword, if this new and most serious enemy is to be checked.

MARK VERNON SLINGERLAND.